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MAY, 1928

Hoover, the Quantifier

Addressing an engineering society some 20 years ago the editor expressed the opinion that the next generation would elect to the presidency of the United States an engineer, for he believed that the age of the forensic adept was about to give way to the age of the engineer. Since then we have witnessed the steady march of the city manager form of municipal government, with engineers outnumbering others as city managers. Now we see an engineer most prominently named as the standard bearer of a great political party. Even if he shall not be elected to the presidency, his candidacy will have brought smartly to the attention of the American people that an engineering training is good preparation for the greatest of executive positions.

We need not tell our engineering readers that their profession is essentially one that deals with economic problems in a scientific fashion. And we need not add for their benefit that there is no fundamental difference between a problem in engineering economics and one in political economics. But it will long remain necessary to tell the public these very things, for the public still has only a vague conception of an engineer's work.

Engineering is the systematic application of science to the solution of economic problems. Hence a well trained engineer speedily adapts himself to an attack upon any sort of economic problem. Unlike the typical lawyer, an engineer is not engrossed in searches for precedents and in putting thoughts into words. To an engineer each obstacle presents itself less as an obstacle than as a problem, and that means a problem in economics. How can I secure the desired end with the least money? This is the question that rings unceasingly in his ears. Since rarely are conditions exactly alike, the proper answer to such a question usually calls for resourcefulness. It always calls for figures. Great precision is not always possible, but some sort of quantification is always possible, and indeed essential to the proper solution of any economic problem. Hence the engineer is fundamentally a quantifier.

Contrast an engineer's definiteness with the vagueness of most other professional men, and you have the prime reason why engineers are becoming increasingly prominent in executive positions. The essence of science is definiteness. And in the most highly developed sciences this means quantification.

As soon as Hoover became Secretary of Commerce he began to gather statistics on prices, outputs, stocks in hand, etc., relating to all our major industries. These are published monthly in a Survey of Business. To paraphrase an ancient saying about Nature, his mind "abhors a vacuum"; and where there are no statistics, there, for him, is a vacuum. But unlike the mere compiler of statistics—the boyish gatherer of bird's eggs—Hoover collects them only because they can be used as economic guides. One of the early results of his statistical surveys was the perception that great wastes were occurring in most industries because too many models, sizes and varieties of product were being manufactured. His campaign against this waste bore notable fruit, almost at once.

We mention this use of statistics merely to illustrate the way in which an engineer's mind works when an economic problem is attacked. Facts delight him more than fancies, yet his imagination is not fettered by figures. He looks beneath figures to see their significance; and very significant figures stir the imagination. If you doubt it, read how Newton was led to discover the quantitative relationship between the rate at which the moon departs from a tangent in traveling around the earth; and thus, soaring in imagination to the confines of space, how he made the grandest deduction in all the history of astronomy—the law of gravitation.

It seems probable that all qualitative differences are at bottom quantitative differences. At any rate physicists have found it to be true that the qualities called colors are merely differences in etherial wave lengths; and that the same holds true of the qualities called radiant heat and light. Our organs of sense are mechanisms by which certain quantities are automatically sorted out, and their effects are then registered on our brains. Because we do not perceive these definite quantities as quantities, but only as sensations, we fail to regard them as quantities of energy, and we call them qualities. Later comes the physicist and shows us that these different qualities differ only in being different quantities, different wave lengths, for example. Then if we are philosophic it begins to dawn upon us that perhaps every phenomenon in Nature's vast array is kin to every other phenomenon, and that the sole difference between them is to be found in the number, grouping, paths and velocities of ultimate corpuscles that are all alike.

At any rate this theory fits so many facts that, if not

unqualifiedly true, it is at least approximately true. So it gives a dignity to quantification that it sorely needs in a world of men who are, for the most part, accustomed to regard "figures" with aversion, and to look upon most "figurers" as being at least slightly abnormal.

Perhaps it will prove to be no exaggeration to say that the election of an engineer to the presidency of the United States will mark the real beginning of the age of scientific politics.

A Plea for Adequate Rewards for Scientists

The lodestone that attracts the most brains is gold. Sordid as this may appear, history quite clearly indicates its truth.

When gold was most readily secured by conquest, the ranks of the warriors were filled with brilliant men. In fact, most of the ancient thrones were thus founded, along with the houses of the lesser rulers.

When gold was most readily secured by skilled craftsmen, great numbers of bright minds flocked into the profession of art. Grecian art, for example, did not flourish so greatly because art was then adolescent, but because it paid well to be a great artist. And again in the pre-Victorian age when opulence became common, portrait painters flourished as they had never flourished before and have never flourished since. De Guerre's invention knocked the profit out of painting; and profit gone, the great portrait painters disappeared. The camera ended their career.

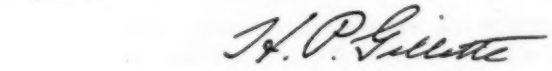
Much of the genius, as well as much of the folly, of the world has been assembled at Hollywood. There the camera has developed a new art that makes the popularity of all previous arts seem small; and coincidentally is bestowing Aladdin fortunes upon the leading artists and business managers alike.

Ever since the "industrial age" was ushered in eight generations ago by the steam engine, manufacturing has offered great prospects of great profit, and has vastly enriched thousands of men. Consequently many of the ablest men of the world have gone into manufacturing. It is this high order of manufacturing ability that accounts largely for America's phenomenal prosperity. By the side of H. G. Wells' phantasmal puppets that are presumed to typify the successful manufacturer, set real manufacturers like Rockefeller, Carnegie, and Ford, if you wish to see some of the reasons why America is great.

True it is that our greatest manufacturers have always leaned heavily upon the shoulders of inventors and engineers, and they, in turn, upon the shoulders of pure scientists. True, also, that the last named have commonly been so ill rewarded that our whole thesis seems to be belied by that fact. But fame to some men is a reward more prized than wealth. It was fame that drew Newton and Faraday and Einstein into the ranks of the scientists. But for every such genius so drawn, probably a hundred men of equal mental power and assiduity have been drawn into the management of manufacturing enterprises, for to the great majority of men, income still takes precedence over laudation, and a mansion is preferred to a mausoleum.

If so, our plea to such men becomes a plea for better financial rewards to the men of pure and applied science. An enlightened self-interest should teach the wealthy manufacturer that greater income for the original men of science and engineering will result in a more eager thronging of their ranks by the geniuses of the world, and this, in turn, will multiply the profits and the power of the executive geniuses who employ them.

There is evidence that this thought is taking hold of great executives here and there. It is seen first, in the fact that about 1,000 research laboratories are now maintained by American manufacturing companies, and, second, in the fact that here and there an employee in these laboratories emerges with a fistful of gold. Still the path to a general acknowledgment of the wisdom of rich pay for researchers is merely a vague trail through the woods of ignorance, its direction blazed now and again on some tree, but only followed by the keenest eye. No highway yet exists that can be truly called The Highway of Payment in Proportion to Performance.



Handy Reference Work

The ROAD AND STREET CATALOG AND DATA BOOK is efficiently filling the need of the active engineer, public official and contractor in the highway industry for information on the latest practice, for cost and engineering data, for comprehensive descriptions of the latest in labor saving equipment, and for information on materials and supplies in use in this $1,500,000,000 industry.

That accounts for the fact that this valuable reference work is commonly kept right at hand on the desk for the "necessary information sought for each day by road men." Hundreds of reports prove that the most active men in the field are appropriating the great service benefits afforded by the ROAD AND STREET CATALOG AND DATA BOOK.

One enthusiastic letter gives the details of the largest contract ever made by the State of West Virginia for a particular road material, and which sale the writer was enabled to effect through an authoritative table given in the Data Section. This table, the officials said, proved his claims and an order resulted.

Public officials report: "We have found this reference work to be of vital importance in our work," and Charles Upham, Business Manager of the American Road Builders' Association, says: "There has been a need for such a catalog where one could find all road equipments in one issue, and I want to say that I think you have supplied the need most admirably."

Occasionally it is possible that one of these books fails to render the efficient service for which it is so well prepared to give because through some oversight it has not been examined and the owner remains unacquainted with its stores of valuable data he might so easily acquire the benefit of.

If any active road man happens not to be enjoying the great benefits of this handy reference work he should make application for a copy while it can be supplied.

Badly Needed Drives Built on Made Land in New Park Project

Through Traffic Boulevard and Park As Part of City Plan of Chicago Under Way

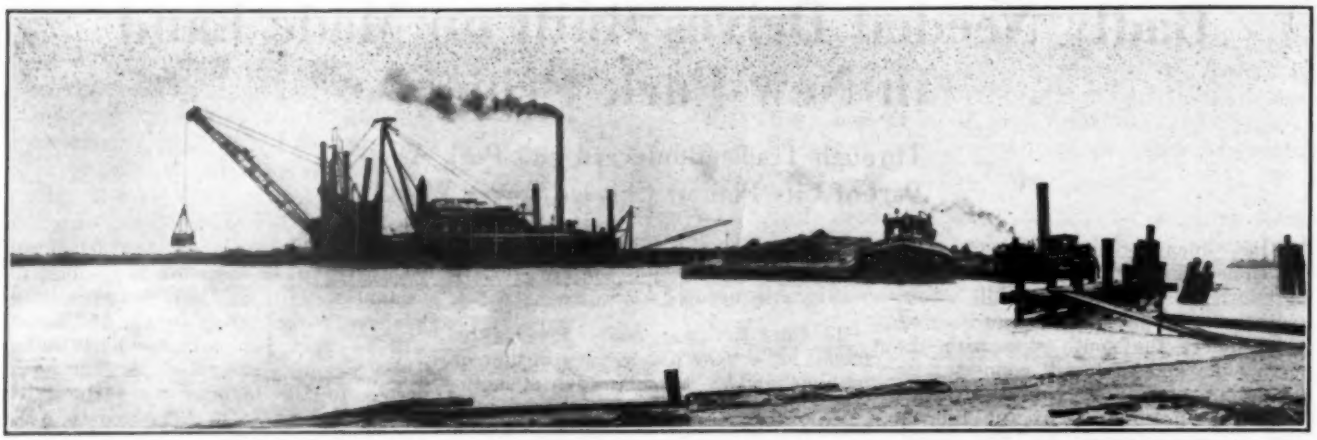
THE Chicago South Parks Commissioners are at present involved in an enormous project that will afford two new high speed traffic arteries that will connect the south side with the north side, and that will connect with a similar plan now being advanced in their own territory by the Lincoln Park Commissioners on the north side. The work being done on the south side is a part of the comprehensive City Plan that has been evolved by D. H. Burnham, the famous city planner and architect, with the cooperation of other planners, and it provides badly needed traffic arteries along the shore of Lake Michigan that will permit through traffic to be expedited by means of a routing that will not involve passage through the congested downtown business section. Not only does the plan include splendid through streets of scenic as well as practical value, but it includes as well the development of miles of park, bathing beaches, and other recreational facilities along a shore line that previously was partly devoted to railroad tracks.

This project was made possible by means of a very extensive program of making land by a combination of methods, thus moving the lake shore outward and providing grounds that would not otherwise have been available without expensive condemnation of valuable property.

Extent of Work.—The project in the jurisdiction of the South Park Commission, that involving the work south of Randolph Street and extending to Jackson Park and including Grant Park, involves a total fill of 1,100 acres over a length of about 6½ miles. It provides a strip of made land along the shore 300 to 500 ft. wide, then a series of lagoons 400 to 500 ft. wide, and on the outer side of these lagoons a series of islands running from 400 to 2,000 ft. wide. The total fill will aggregate about 50,000,000 cu. yds. by the time the work is completed. Channels will be left between the islands, four channels in all, and these will be spaced about one each mile. These channels are intended to provide access to the lagoons as harbors of refuge and yacht harbors and to provide free circulation of water between these lagoons and Lake Michigan. A wide drive will be built along the inner strip and another through the chain of islands, the latter crossing from island to island by means of bridges spanning the channels, and the drives interconnected at half-mile intervals by bridges spanning the lagoons. At the same points, viaducts will be built spanning the tracks of the Illinois Central Railroad that runs along the old shore to connect with existing city streets. The inner and outer drives will converge at the Field Museum in Grant Park and on the southern end of the project. Grade

(Chicago Aerial Surveys)

Aerial View of Fill South of Grant Park Showing New Island, Bulkheading, Completed Fill, and Progress on Roadway



Scow Fill Being Made Behind Bulkhead, and Dipper and Clamshell Dredges Keeping Channel Open

separations will be made at all intersections in order that no line of traffic will cross another on the same level and provisions will be made for pedestrians as well.

The inner drive, known as Lief Ericsson Drive, located on the shore strip that will be known as Burnham Park, is to be 70 ft. wide. This drive is now in use from Grant Park to 23rd Street, and is under construction from 23rd Street south, and will be advanced as the fill is completed. Since the pavement is to be placed on new fill, these drives are being constructed of asphaltic macadam with rock asphalt surface.

Structures.—For the most part the bridges and viaducts will be built of structural steel, of the girder type, encased in concrete, resting on concrete piers and abutments, but some of the shorter spans may be built of reinforced concrete. A total of 28 bridges and two subways have been planned.

Underground Work.—The necessary underground services are being installed as the work progresses, such as storm sewers, water mains, sanitary sewers, electric conduits, etc. The sanitary sewers will be carried across the railroad and drain into the city system interceptors, while the storm sewers will outlet into the lake. The fill will be covered with black dirt to a thickness of at least 10 in., while at the point where trees and shrubbery will be planted the depth of the black dirt will be 18 in. or more. This black dirt is to be shipped to Chicago by rail and hauled to the park by motor truck. Separate contracts will be let for planting and for sidewalks, etc.

Letting the Work..—This work to cost about $100,000,000 in all, was started in the fall of 1920, and is progressing as rapidly each year as funds permit. The work is being let in sections of varying length and yardage, in each case to the contractors who were able to make the best bids or combination of bids for that section. In this way fill methods vary with the section, with only one contractor involved in some cases and with several involved in others, each with his own method of filling. For the past two or three years the filling has progressed at the rate of 2 or 3 million cu. yds. a year, and to date the project is about 25 per cent completed after an expenditure of about $21,000,000.

Bulkheading.—The first step in the progress of the work is the construction of the bulkheads that will act as breakwaters or seawalls and that will retain the fill. A triangulation net was first laid out from the shore, range piles driven, and soundings made. These range piles not only gave a guide for further bulkheading operations, but gave a measure of the pile lengths necessary to complete the job according to the specifications. During this stage of the operations it was found that 50 ft. piles were required at the north end, while the shortest that were needed were 35 ft. Specifications called for piles of mixed hardwoods, including cypress, with 12-in. butt and 6-in. point, driven to grade in about 20 ft. of ground, thus requiring good penetration into clay. The piles were driven to 5 ft. above the water line, the waterline being approximately datum.

The bulkheads were constructed of double rows of piles close driven, except where sheet piling was used, with timber walers on the inner row and steel channel walers on the outer or water side of the bulkhead, with bolted tie rods tying the the two rows together at the walers, and the space between the piles filled with stone. In some cases Wakefield sheet piling was used, sometimes on the water side of the bulkhead, sometimes in between the piling, but for the most part on the fill side, with the adjacent piling spaced on 2-ft. centers, and with the tie rods running through the sheet piling as well as through piles and walers. The steel channel walers, of 18 in., 16 lb. per ft. steel channel in 30-ft. lengths, were used on the water side since they have been found to be more resistant to ice action and damage from boats than timber walers. These were turned flat side to the piling and the ends spliced with splice plates as are railroad rails. These channel walers were found to conform to curves as well as to tangents with but little manipulation. Timber walers on the inside were of two 6 by 12 timbers with the 12-in. dimensions vertical, and so laid in a staggered position that they made a build-up continuous 12 by 12 waler. On the rock sides of the piling a single row of 6 by 12-in. walers was used. Each pile was bolted to the waler, and tie rods running through the entire assembly were spaced on 4-ft. centers. Each bolt or tie rod was equipped with nut and washer on each end.

The rock fill used was quarry run waste limestone in sizes up to 1 ton and graded so as to make a compact fill, while a top dressing of cover stone was used to finish off the work, made up of specially selected stone of a minimum weight of 1 ton. Even this large stone has frequently been dislodged and moved a hundred feet or so by wave action, so the size of this rock, particularly of the cover stone, is of real importance.

Where the ground is soft or where for any other reason additional strength is needed, riprap is deposited against the bulkheading. This riprap is composed of limestone in the same sizes as the core rock, with coverstone of the larger blocks already described.

First Fill.—The work of building up the fill proceeds essentially in four lifts. First somes the general fill that brings the fill to just above the water level. On top of this comes the embankment fill, which is followed by any additional fill required for the roadways. The final fill consists of the laye of black dirt required for the planting scheme. While this latter work is done entirely separately, somecontracts have been let on the basis of the same equipment being used to make the first three fills in one operation, while others have been let on the basis of one contractor doing the first, another contractor doing the second by other methods, while the roadway may or may not be built up as a third op-

eration. The first fill can be made in three different ways, and all three are being used, while the second and third fills can be and are being done by two different methods.

Dredge Work.—As soon as the bulkheads had been constructed, the work of bringing the land up to datum was begun. Here a combination of methods was used. Scows of spoil from buildings and other excavations were hauled in and dumped where required until draft needed for this mode of transportation was no longer available. A large dipper dredge and a clamshell dredge were used to keep channels open and to rehandle the material thus dumped, by cut and cast, in order to build the materiel up to about datum.

Hydraulic Dredges.—On the north end, where the bottom was found to be of clay, ladder dredges (suction dredges) were used in conjunction with a pipe line to make the same sort of fill. To the south, where the bottom was found to be a shallow cover over rock, and with two reefs actually breaking the surface, the use of ladder dredges was not feasible, and while the dumping of spoil from barges could still be counted upon for a part of the fill, a third method had to be resorted to. This method, useful over the entire length of the job where contracts had been awarded on that basis, consisted of picking up a load of sand in a sand boat about 14 miles from the job, transporting this sand in the sandboat to the job, and then discharging the load from the hold to the fill through a pipe line. A great deal of the fill has been made in this manner.

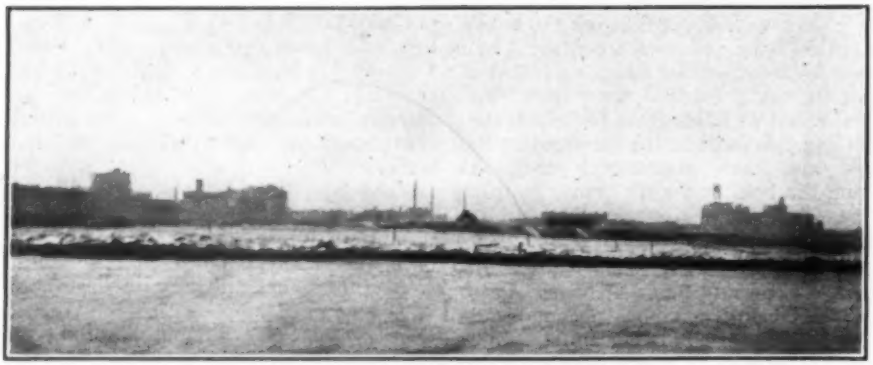
Embankment Fill.—The next lift, that of general grading above the water level, is being done by the sandboats, and this method is being supplemented by dumping from motor trucks, which obtain their material from building and other excavations throughout the city. While the usual practice with sandboats does not include the building up of roadway embankments, high banks, etc., one of the sandboat contractors has patents covering such fills, and his methods are being used on the portions of the work being done by his concern. This contractor, the Construction Materials Company, by means of high pipe lines, clay or sand and canvas dykes, and drains, is able to build up to any level encountered on this job, and to build up a fill that conforms to any ordinary area, roughing out any landscape or roadway fills to line and grade at a reasonable cost. Two of his sandboats, both of large capacity, are being used on this work. Similar boats are being used by other contractors on other sections of the work.

Roadway Fill.—Final preparations for the roadways is made by building up a clay sub-grade by hauling in clay on motor trucks from various excavations throughout the city. This fill is of course well compacted by the trucks as they drive over it, but a rolling is also specified, using a 10-ton roller. Besides this type of subgrade, ordinarily fill is secured in the same way at the rate of about 10 acres a year. some subgrade is built up by the sandboats.

Underground Work.—Prior to paving, all underground work is done under separate contract, using ordinary methods. Since this involves only trenching with an ordinary trenching machine, laying the pipe and conduits in the established manner, and backfilling with backfiller, no further description of this work needs be made at this time.

(Chicago Aerial Surveys)

View of Work North of Jackson Park Showing Progress on Inner Drive

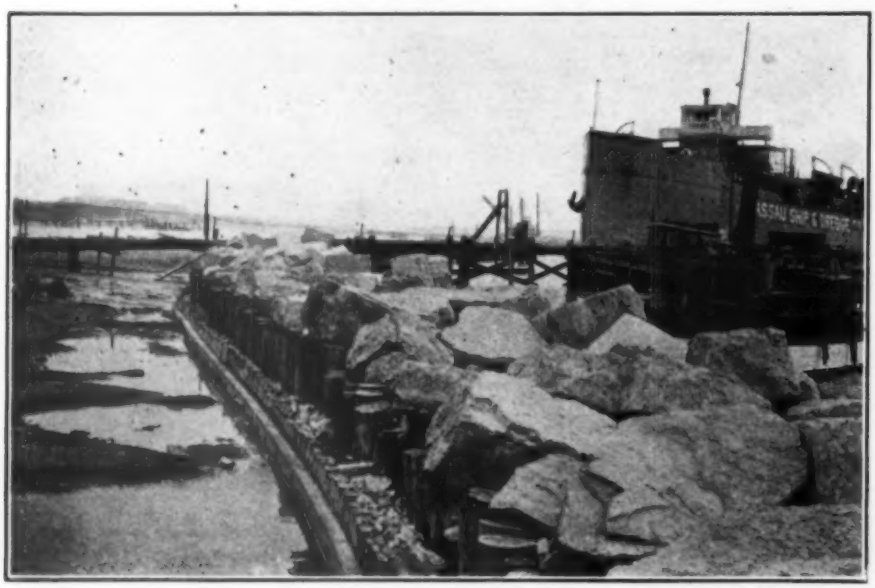


Trucks Making Fill for Inner Drive, as Seen From the Lake

Paving.—As soon as the roadway fills are completed and fully compacted, usually allowed to season for a year, the paving operations are begun. Here the subgrade must be finished and a macadam or concrete base be laid for the sheet asphalt pavement. No paving was under way at the time this article was written, so the methods used on this part of the work cannot very well be described.

Underground Work in Progress With Trencher at Work

Summary.—This work is being done for the South Park Commissioners, represented by Linn White, chief engineer, and John P. Ball, resident engineer, by a number of contractors. Bulkheading was done by the Great Lakes Dredge & Dock Company, and this same firm are utilizing scow fill and operate hydraulic dredges, dipper dredges, and floating cranes. Their work is done under the active direction of Capt. Wm. Murphy, who is assisted by Carl Nelson, superintendent, and Robert Ketchum, assistant superintendent. Sandboat equipment is operated by three firms, each using two boats. These are the Central Dredging Company, operating the "Bay View" and the "Chicago"; Construction Materials Company, operating the "Sandcraft" and the "Sandmaster"; and the Illinois Ship and Dredge Company, operating the "Brazil" and the "Nassau." The Great Lakes Dredge & Dock Co., operates the "New Jersey," a 30-in., 4,000 h.p. Diesel electric hydraulic dredge; the "New York" and the "Illinois," two steam driven hydraulic dredges; the "No. 21," an 8-yd. dipper dredge; the "No. 48," a 7-yd. dipper dredge; and other floating equipment. Contracts are let in sections on the basis of the best bids for all work or parts of work in that section, accounting for the variety of methods used.



Inner Face of Bulkhead With Sheet Piling. The Large Vessel Is a Sand Boat Making Fill

Stock Salt Used to Melt Ice Surface

On the Pacific Highway in the vicinity of Weed, Calif., difficulties are encountered by the freezing of snow and the formation of ice on the concrete pavement. This is particularly true on curves, especially where occurring on maximum grades.

This condition, in part, is overcome, in so far as slipperiness is concerned, and the road rendered reasonably safe for travel, by a thorough sanding of the surface. Under this method there is a tendency to build up the ice sheet and prolong the hazard to the public, as well as materially increasing maintenance costs, due to purchase of materials and their daily application. In an endeavor to overcome delay, to reduce costs, and render better service to the public, various substances and methods have been tried in the past on the ice sheets. The results indicate that the application of approximately 50 lb. of stock salt to 400 lin. ft. of 18-ft. pavement, evenly broadcast by hand, will so decompose an ice sheet two to three inches in thickness, that in the course of four or five hours it can be removed by means of a towing grader powered by a 30-h. p. tractor.

The use of salt is not advanced as a cure-all for ice conditions. Its use, however, is justified at times, especially when melting is delayed, or where grades or curvature make it imperative to remedy the condition at once, and where sanding is either not economical or ineffective. For the treatment of the block ice or thin glaze, sanding by means of hand shoveling or spreader trucks is the most effective.—California Highways and Public Works.

Iowa Awards $796,562 of Highway Contracts.—On March 27 the State Highway Commission of Iowa awarded contracts for 21 miles of hard paving, nearly 30 miles of grading, and construction of 91 bridges and culverts.

Eliminating One Theory as to the Cause of Hair Checking in Concrete Road Slabs

Lack of Moisture Not Primary Cause of Checking

BEN H. PETTY and H. E. FILLINGER

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ONE of the most baffling phenomenon connected with concrete road paving is that of hair checking or "crazing" on the surface of the slab. Inquiries sent to such organizations as the Bureau of Standards, Bureau of Public Roads, Highway Research Council, Portland Cement Association and other similar sources of authoritative information have disclosed the fact that information regarding causes of hair checking in concrete slabs is very limited.

This article presents the results of an investigation undertaken as a basis for a graduate thesis during the summer of 1926. Observations of hair checking were made in Indiana on a section of U. S. Road No. 41 from North Terre Haute to Lyford, a distance of approximately eight miles. Paving was started May 6th and ended Aug. 7th. The data for this thesis covers the period from May 18th to the end of the paving period.

The road was built under the standard specifications of the Indiana State Highway Commission using a 1:2:3 mix with a maximum slump of 2 in.

The coarse aggregate was a washed gravel and the fine aggregate was washed sand from the same source. A standard brand of cement was used which passed all tests required by the U. S. Bureau of Standard's Circular No. 33. These tests were made at the Indianapolis laboratory of the Indiana State Highway Commission.

A Lakewood finisher with tamper attached, tamped and finished the concrete. The second belting was done by a hand operated belt machine which followed at a required distance behind the finishers. The pavement was straight-edged ahead of the final belter and at all places where a ¼ in. variation under a 10 ft. straight edge was evident, corrections were made by means of long handled floats.

The curing consisted of covering the slab with straw the morning after the pavement was laid, then sprinkling it for 14 days. The straw remained in place until the slab was 21 days old, at which time the road was opened for light local traffic to provide an outlet for farmers.

Securing the Data.—Some of the data was taken under great difficulties. The usual duties of a project engineer present a full program and this investigation had to be worked in extra. Having an experienced and interested inspector on the mixer was a great help, for he was fully capable of observing conditions and making the necessary notations when the period of hair checking started. By the time the project engineer had arrived on receipt of the inspector's note, the latter usually had the area plotted, was applying the preventatives prescribed and noting the reactions. The contractor's bookkeeper was also a valuable assistant in taking readings at the plant when it was necessary for the project engineer to be away setting stakes or performing other engineering duties.

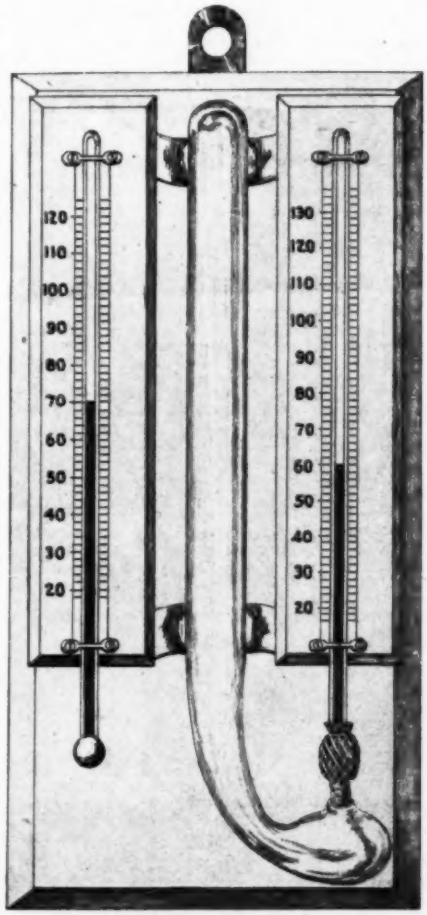

Fig. 1—The Hygrometer

Readings were taken from the hygrometer the first thing in the morning and repeated at two hour intervals, or less in case of change of atmospheric conditions. Upon the appearance of cracks, the bookkeeper was notified by the inspector and readings were then taken every half hour or hour, depending on the change of the atmospheric relative humidity. These readings on the wet and dry thermometers were entered on specially prepared forms. The relative humidity referred to in this experiment is the percentage of moisture in the air, using a saturated atmosphere as 100.

The hygrometer used was a form known as "Mason's" hygrometer (Fig. 1), consisting of two mercury thermometers, one of which was used as a dry bulb thermometer and the other a wet bulb kept moist by a wick and a bottle of distilled water. The wet bulb was fanned vigorously for approximately a minute before the reading was taken to insure a correct reading.

The aneroid barometer was a surveying barometer reading to 1.0 ft. of altitude and to 0.2 in. of mercury.

The testing department of the highway commission requires a weekly report of material tests on aggregates as well as a report on slump tests. These tests are generally made on Saturday in order that the gravel producing companies can make the necessary changes in their plant on Sunday and not hold up the production. The material on this job ran very uniformly and only slight changes were necessary.

By the aid of extra screens, it was possible to obtain the fineness modulus of the sand for each week's supply.

The temperatures on dry bulb readings were tabulated for each day on which pavement was laid. The relative humidity was recorded for the same period as shown by the dry bulb readings and computed from the difference between the wet and dry bulb readings by specially prepared tables of the U. S. Weather Bureau.

Results and Conclusions.—The steadiness of the temperature during the day is contrasted with the fluctuations of the relative humidity in Fig. 2. These graphs indicate no direct relation between the two. This is actually true, as the air can be saturated with moisture at most any temperature between the freezing and vaporizing points.

The theory which seems to prevail in the minds of most engineers is that

hair checking occurs when moisture is being absorbed rapidly by the atmosphere causing the surface of the slab to dry out and contract more rapidly than the material just under the surface. If this theory were true, we would always have hair checking when the relative humidity dropped below a certain point, say 30 or 35 per cent saturation. Fig. 3 shows the relative humidity on days when hair checking was in evidence, plotted against the average relative humidity for the whole period from May until August. This graph shows only two days, when hair checking took place, on which the humidity plotted below the average for that entire period.

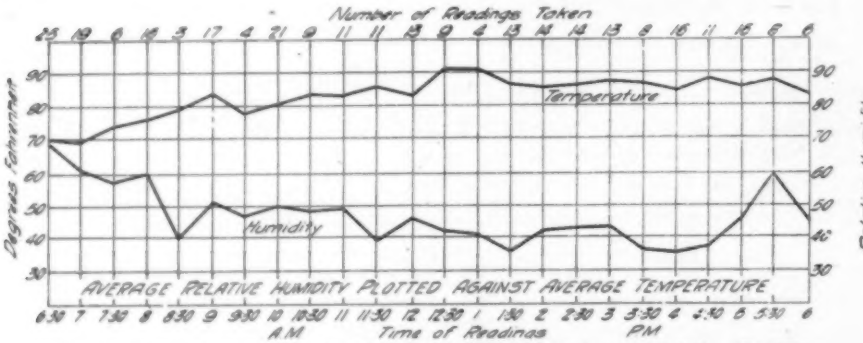

Fig. 2—Temperature During Day Contrasted with Fluctuations of Relative Humidity

On the other hand, if we plotted the lowest readings taken at each period during the summer when no hair checking was in evidence, we could construct a line below the lowest one on which hair checking occurred. This proves that there were periods when the relative humidity was much lower than at any time when checks appeared. The graphs showing this important feature are exhibited as Fig. 4.

The hair checking was not confined to any particular part of the surface. Generally it did not extend over the surface more than 200 or 300 lin. ft. The hair checks that occurred in number were plotted on specially prepared charts. These show the station numbers of the checks and the half day on which the concrete was placed, as well as the length of time after being placed before checking appeared. The slump test and condition of the subgrade were also noted to make the record more complete.

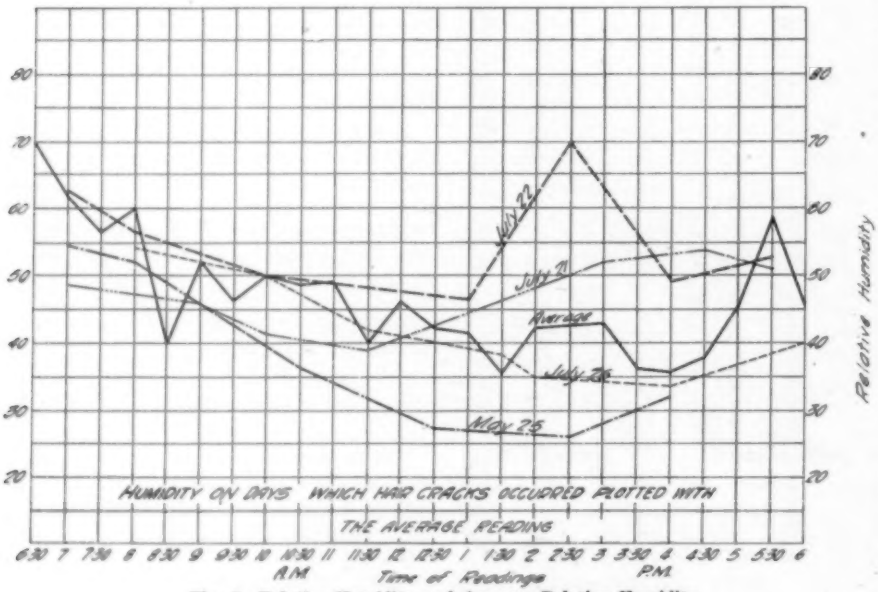

Fig. 3—Relative Humidity and Average Relative Humidity

The fineness modulus of the sand shown in Fig. 5 indicates that the material varied about an equal amount each side of the average, making a difference between the fine and coarse grades of about 27 points in the most extreme case.

The data indicate that hair checking occurred under average ordinary conditions of summer weather in a season which, according to the weather bureau, had a rather high humidity. In one case, at the instant checks appeared, the entire surface was flooded with a film of water and pavement too "green" to stand the pressure of the sprinkling water was covered with a layer of very wet burlap. This did not seem to stop or even retard the rapidity with which the checks opened up on the surface. Nor did they close, but remained open until the inspector had them filled with neat cement the next day. This apparently proved that lack of moisture was not the primary cause of the checking, else none would have occurred on the surface of the "green" pavement under the wet burlap. Checking sometimes occurred the following morning after the concrete had been poured, indicating further that the cause was something other than the lack of moisture on the surface.

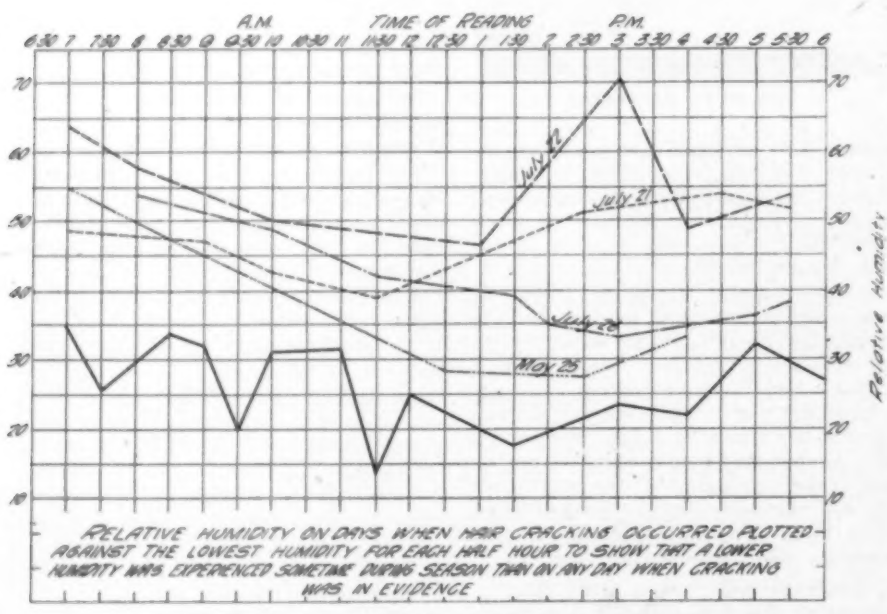
A.M.
TIME OF READING
P.M.
Relative Humidity
July 22
July 21
July 26
May 25
RELATIVE HUMIDITY ON DAYS WHEN HAIR CRACKING OCCURRED PLOTTED AGAINST THE LOWEST HUMIDITY FOR EACH HALF HOUR TO SHOW THAT A LOWER HUMIDITY WAS EXPERIENCED SOMETIME DURING SEASON THAN ON ANY DAY WHEN CRACKING WAS IN EVIDENCE

Fig. 4—Relative Humidity Compared with Lowest Humidity

Suggested Future Investigations.—The curve shown in Fig. 5 is too incomplete to have a bearing on the theory that the fineness modulus of the aggregate affects hair checking. This theory should be investigated further. It is almost impossible to vary the fineness modulus in the field during actual work. Such tests would have to be handled on a laboratory basis. Bins

of materials with different fineness moduli would have to be constructed, mixes pushed to extremes to create the desired situations and corrective measures applied by changing the mix until the most satisfactory condition was obtained. No doubt this shifting of materials would place the concrete outside the bounds of a workable mix and other conditions would then enter into the work that would complicate the causes and results.

Another investigation that should be carried along with the above is the determination of the surface modulus of the "green" concrete. It would be possible to determine the difference and rate of change of the surface modulus with the change of the fineness modulus.

The Bureau of Standards has suggested that possibly a difference in various brands of cement might make hair checking more apparent. There is some opposition to this contention, as Indiana purchases cement from all mills in the state and yet we have hair checks in practically every job. However, there may be some difference in chemical composition of various batches or bags of cement in a shipment that would cause them to take their final set much quicker than the standard grade. Since the cement is always in the pavement before the checks appear, a sample for investigation would have to be held from each batch and the location of each batch charted. On a field job this would be impractical as it would mean over two thousand samples a day with only a slight chance of getting a hair check.

Any of the above experiments would have to be carried on in the laboratory or if performed in the field would require much more apparatus than is usually available and would have to be in charge of a special corps rather than in conjunction with the usual duties of a project engineer.

However, there is a line of investigation that should be carried out in the field which is possible without much inconvenience and added equipment, namely, the moisture content of various materials. Material of all moisture contents from the dryest source in the stock pile to the material taken from a car after a rain would give a wide range of values. When this field has been investigated and cleared up, the bulk of further investigations will fall directly in the laboratory along chemical rather than physical lines.

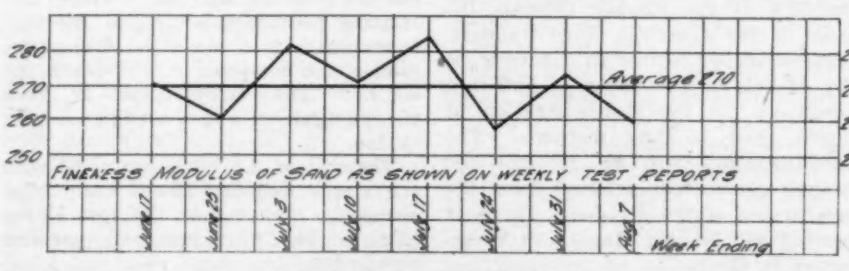

Fig. 5—Fineness Modulus of Sand

A Call for Bids in 1827

The following is an official advertisement for bids for constructing a section of a road from Detroit, Mich., to Chicago, Ill. This official notice was printed in the Detroit Gazette in 1827, over 101 years ago:

Public Notice

Is hereby given, that in order to carry into effect the act of Congress, providing for laying out and making a road from Detroit to Chicago, the construction of the different subdivisions of the road, laid out by the commissioners under that act, beginning at the first ¼ mile post on the south side of the River Rouge, near Ten Eyck's Bridge (so-called), and extending to the first ¼ mile post south of the Willow Run (so-called), will be offered at public sale, to the lowest bidder, at the Council House in Detroit, at 11 o'clock, A. M., on Tuesday, the 5th day of June next, and at Ypsilanti, in the county of Washtenaw, on Friday, the 8th day of June next, at 11 o'clock A. M., in such proportions at each place, as by the superintendent may be deemed expedient. This section of the road presenting the most formidable obstacles, it is thought best to finish it in the most complete and permanent manner, and to appropriate to this object such a portion of the general fund as will effect it. When this amount is ascertained, the remainder will be equitably proportioned among the other parts of the road.

Every quarter of a mile, as the same has been laid off by the commissioners, will be offered separately. One approved security will be required for the faithful performance of each contract. The whole work must be completed on or before the 15th day of May, 1828, and will be reviewed on that day.

When the person appointed to inspect the work, shall decide that one-half of it is completed, then one-fourth of the consideration money will be paid. And in like manner, another fourth will be paid when three-fourths of the jobs are finished. When the same person shall decide that the work has been fully completed then the residue of the money shall be paid, with the exception of fifteen per cent, upon the whole amount; which will not be paid until the inspection and acceptance of the road, immediately preceding or upon the 15th day of May, 1828, at which time every part of the road must be in perfect repair.

The whole progress of the work will be directed and inspected by the person appointed, or by such other as may hereafter be appointed under the direction of the War Department, for that purpose; and it must be completed to the entire satisfaction of such agent or superintendent. And it is to be distinctly understood, that every part of the work must be finished in the best manner, and that no job will be accepted, until it is completed strictly according to the contract.

Information will be given to all persons who may apply, regarding the mode of construction of the different parts of the road, as soon as a sufficient examination can be made of it, and in time to enable persons to form an estimate of the value of the work.

Separate contracts will be entered into, for building Bridges over the Huron and Saline, provided, that after the sales of such parts of the Road as are before designated, there should remain funds sufficient. These Bridges must be built in the best and most substantial manner, and a plan will be required of each contractor, showing the mode in which he proposes to build them.

Contracts will in like manner be entered into for the building of other Bridges (if necessary), of which information will be given to all persons who may apply as soon as the Road is examined, and it can be ascertained where and how they ought to be built. These contracts for Bridges will be offered at the days and places before designated.

After the foregoing sale shall have been made, should there still remain funds applicable to the object, such other parts of the road will be sold at auction, as the Superintendent may direct.

The right will be reserved to the United States, of adjourning the sale at any time, should the person superintending it, believe that the prices which may be required for the work, are more than the public interest would justify him in allowing.

MUSGROVE EVANS,
Superintendent.

Detroit, May 2, 1827.

New Spark Control for Climax Engines

The Climax Engineering Company of Clinton, Iowa, has perfected and now offers for sale, on its heavy duty industrial engines, a new Automatic Spark Control.

This device operates on an entirely different principle than the conventional centrifugal governor type so common in automotive practice. The new spark control operates from the suction in the intake manifold. As the variation in pressure in the intake manifold is proportional to the load imposed upon the engine, the ignition is always timed correctly, no matter how the power varies on intermittent loads, according to the manufacturers.

By timing the spark automatically, this new device does what operators could not possibly do by hand.

There is little loss of power and the fuel consumption decreases to a point where a saving of 10 per cent on fuel is attained on intermittent loads, such as are encountered in earth moving machinery, locomotives and similar classes of equipment, it is claimed. It will reduce spark knocks and reduce wear on bearings.

The Automatic Spark Control can be quickly installed in the field on any model Climax engine. The small additional cost of installation is offset in a few months by the saving it affords in fuel consumption, the manufacturers say. This new spark control can be applied by Climax Service Stations.

This is one of the many new exclusive features that the Climax Engineering Company is incorporating on its engines to meet the present day need for modern and up-to-date power equipment. A letter addressed to the Climax Engineering Company, Clinton, Iowa, will bring complete information.

Motor Highway Proposed in Spain.—M. L. Spofford, U. S. Consul at Madrid, reports that Spain proposes to construct a motor highway, to connect Madrid with the French frontier at Irun, the cost of which is estimated at 240,000,000 pesetas, or 600,000 per kilometer, and its completion within four years is promised. A few months ago it was formally promised for the end of 1928. Work has not yet been commenced. (1 peseta equals $.1690.)

Snow Removal at Toronto

Methods Described in Paper Before International Association of Street Sanitation Officials

By GEO. W. DIES
Street Commissioner, Toronto, Ont.

TORONTO'S climatic conditions are similar to those of the majority of cities in New York state and the Northern states. We have no long spells of severe weather, as is generally supposed by our neighbors in the south.

Our winter season's set in round the latter part of December and break up in March. We are usually well advanced in our spring cleaning by the first week in April. The total snow fall during the winter season of 1926-1927, amounted to 45.5 in. The maximum fall at one time amounted to 5.9 in., while the mean temperature for the three winter months, January, February and March, was 21.3°, 27°, and 35.2° respectively.

Toronto covers an area of 32.32 square miles, with 562 miles of streets, 147 miles of lanes, and a population of 560,000, as returned by the Assessors. The street railway system is owned and operated by the city, and has a single track mileage of 197 miles.

Organization Principal Factor.—Organization is the principal factor in the effective and economical removal of snow. The first step each fall is the preparation of a map defining each district, location of foremen and disposal points. The patrolmen are organized in small gangs under the supervision of a sub-foreman. Additional casual labor is engaged as conditions warrant it.

Each foreman is responsible for his district. He has his men placed in gangs of 12 to 15, stationed at given points, and all working in the same direction. First attention is given to the business section and main car lines, crossings for pedestrians, and car stops, while the opening of channels in the vicinity of culverts is performed by small gangs working in defined areas.

The snow plow is used most advantageously for drifts and windroving the snow to each side of the roadway, thus permitting the teams and trucks to be loaded as quickly as possible.

Clearing Car Line Streets.—On car line streets the Transportation Commission operate snow plows mounted on flat cars, followed by rotary broom sweepers, all of which are equipped with steel blades, mounted upon swinging arms, which push the snow 8 to 10 ft. from the track allowance into a windrow. The congestion and parking of motor vehicles is perhaps the greatest handicap in the performance of the work, while it must be borne in mind that it is also the primary motive for the removal of the snow.

The commercial and flexible utility of the motor vehicle today demands that street officials place snow removal among the essential civic services and give it considerably more thought than it was given 12 to 15 years ago, when snow cleaning was confined to a very limited downtown area.

The most effective solution for fighting a snow storm is to work with the storm, in this way the snow does not become packed too firmly to be easily handled and guards against the danger of blocking traffic.

Disposal of Snow.—The disposal plays an important part in the economical removal of snow. Long hauls necessarily reduce the loading time. Therefore, sewer man-holes are utilized where possible. The construction of special snow holes at convenient locations has greatly relieved the situation, owing to the greater capacity of the hole and the fact that the disposition of the snow is accelerated by a flow of water from a water main.

The depositing of snow upon vacant lands, ravines, or park areas is found necessary at times, but has the objectionable feature of an unsightly dump until late in the spring before the last of the snow disappears.

Financing Snow Removal Work.—Snow removal work is financed by general taxation, and is included in the Department's Annual appropriation. The city does not remove the snow from sidewalks in front of private properties, but will upon request, the cost of which is chargeable to the property owner and included in the annual tax bill. The street railway system, while being owned by the city, pays 30% of the cost of removing snow from the car and bus lines, and in addition maintains its own gangs for switches, loops and yards.

Standardization of County Road Building Methods.—Thomas J. Wasser, president of the County Officials Division of the American Road Builders' Association, has invited all county highway officials of the nation to join in a movement for the standardization of county road building methods. The standardization will be accomplished through committees selected from the membership of the division. The next meeting will be held May 11, in Washington, D. C.

Chicago Tries Diesel Engine on Mixer

How to prevent employees from filling the gas tanks of their private flivvers from the company fuel supply and the gasoline tank of the concrete mixer, is a problem that has puzzled more than one contractor. Apparently the general average is that for every gallon used by the mixer there is at least one gallon and sometimes two which gets "lost" before it reaches the carburetor.

An unexpected solution of this difficulty was recently obtained by engineers of the city of Chicago during some experimental work in which Diesel engine power has been tried out on small mixers. Since the Diesel engine operates on fuel oil or kerosene the problem of stolen gasoline has been practically solved, and what appear to be decided advantages of simplicity of operation have been obtained.

About 18 months ago Jas. J. Versluis, engineer in charge of water works construction for the city of Chicago, conceived the idea of using Diesel engines on small mixers and as a test job a Marsh-Capron 7-S portable mixer was purchased without power plant and fitted in the city shops with a 6 horsepower, one cylinder Hill Diesel engine.

During the past year and a half this piece of equipment has been in continuous use on sidewalk, foundation and other general work for the city and has given such satisfactory results that similar engines are being installed on several new pieces of equipment, including a 10-S mixer.

Outside of the fact that a considerable saving on fuel costs has been effected, as the kerosene used does not interest gasoline thieves, the Chicago engineers have become convinced that due to its reliability, simplicity and ease of operation the one cylinder Diesel engine is a worthwhile power plant.

No difficulty has been experienced in starting on the fuel on which the power plant runs even in cold weather, it is said, and the engine has been found to start as easy or easier than gasoline engines under all conditions. The mixer has been used throughout the test in the normal way and without special attention. For the most part Foreman F. L. Courtney has left the handling of the engine entirely to the laborers employed on the job and there has not been the slightest trouble. The starting procedure is simple. All that is necessary is to open the fuel valve, release the compression and crank the engine. The compression is then thrown back on and the engine begins to fire.

The cost of the mixer equipped with the single cylinder Diesel runs from somewhat higher than the cost of the same mixer with standard gasoline equipment.

The Railroad Grade Crossing Problem in Wisconsin

Paper Presented at Mississippi Valley Conference of State Highway Officials

By HARRY D. BLAKE

Grade Crossing Engineer, Wisconsin Highway Commission

THE railroad train is recognized as an outstanding menace to the safety of the motorist, and to the highway engineer attempting to increase the speed, ease and safety of motor travel, the railroad grade crossing presents a question of procedure complicated in the extreme. The problem has been with us since the construction of the first railroad but it has increased rapidly in importance with the recent development of the transportation system of the country until it is today one of the most serious confronting the American public. The demands of the public and of the railway companies are essentially the same:—the diversion of motor traffic from the maximum number of grade crossings at the minimum of expense to each, and as a result the apportionment of cost becomes the controversial feature. For many years, highway, railroad and public utility commission officials have been seeking an equitable method of procedure. Conflicting interests have developed, however, and in the absence of any generally accepted plan the solution in many cases has been an order by the public utility commission which has reconciled the facts at issue to the extent permitted by the statutes in the particular state.

The Wisconsin Plan of Procedure.—The Wisconsin Highway Department has developed a plan of procedure based in part upon an apportionment of the increased construction cost brought about by the presence of the railway tracks, which appears to offer a reasonable and equitable solution of the problem and one that seems satisfactory to the public, the railroads and public utility commission officials in that state. The progress made during the last year would indicate that the plan is sound.

The average citizen has little patience with bells, signals, gates or watchmen, effective as they may be at times, but demands the removal of the grade crossing in its entirety. During the long period of horse-drawn traffic many people came to believe that the railroads in some intangible way were resposible for all the crossing accidents and, consequently, should pay all or at least a major portion of the cost of improvements of this type.

The reaction of railroad officials to this earlier viewpoint of the public no doubt has been much the same in all the states. The highway engineer from necessity is forced to combine railroad grade crossing improvements with longer road construction jobs in order to make funds available for the grade separation or traffic diversion and frequently the crossings included have not been the ones considered most worthy of attention by the railroad engineers. The question of alleged benefits to the carrier when but 90 per cent or perhaps even less of the total motor traffic was diverted from a crossing has been met with the argument that so long as the grade crossing remains open, the hazard still remains. A contention that the number and character of train movements rather than the volume of motor traffic should be taken as the controlling factor in determining the benefits to each has been presented on many occasions. A frequent source of dispute has been the demand of public officials that the railroads participate in the cost of road construction adjacent to proposed separation structures made necessary in the design of the highway to permit its safe operation when the separation might be effected by the substitution of steep grades, poor alignment and lessened vision for the motorist.

Railroad Track Detail of Topography.—This involves consideration of the question as to whether the railroad track is to be accepted as a detail of topography or whether it is an extraneous feature, the existence of which causes the increased highway construction cost necessary to divert motor traffic from the crossing and toward which the railway company by statute is required to contribute in most states.

It is argued by many railroad officials that the so-called dangerous crossings should be taken up first and the questions of approach grades, vision, highway and railway alignment adjacent to the existing crossing, character of surfacing, speed of trains, and many other factors, enter. It has been generally assumed in the past that the so-called wide open crossings in level country with no obstruction to vision were to remain at grade perhaps indefinitely but with the rapid construction of a tremendous mileage of concrete pavement and the development of high speed through routes, railroad statistics show that 70 per cent of their crossing accidents occur in daylight, 63 per cent on the so-called wide open crossing, a large majority of them caused by motorists entirely familiar with the crossing, and from 25 per cent to 40 per cent brought about by motorists driving into the side of standing or moving trains. A study of these statistics shows that the highway departments and railroad engineers must give consideration to the separation of the crossings where there is no railroad cut or fill to assist, and it is obvious that this work will be expensive. In any event it is difficult to say which are the safe crossings.

Financing Grade Crossing Improvements.—Most railroads have insisted that grade crossing improvements must be financed in their entirety from operating income and that in asking them to contribute toward their cost the public must consider the earning capacity of the line and the responsibility of the railroad officials to their stockholders. This method of financing work of this nature as almost universally employed is at least open to argument and a subject for serious study on the part of both the railroads and the public. Problems presented by the development of tributary roads which utilized crossings previously avoided by a relocation of the main trunk and many other questions of a similar nature have been interposed to complicate the situation and make more effective the claim that the advantages to the railroad would be but temporary at best and that the real beneficiary was the motorist who should pay the major portion of the bill.

At the same time, in fairness to the railroads, we must remember that when their tracks were laid they were located to conform with conditions of that time. Legislation, court decisions and precedent were formulated during the long period of horse-drawn traffic, and it is but fair to assume that the railroads could not forsee the tremendous development of motor traffic that has occurred in the last 20 years. The responsibilities of the railroad corporations to the public, however, are quite clearly set fourth in the statutes in the various states and to these laws both parties at interest must conform.

Accidents at Grade Crossings.—With the development of motor transportation during the last few years, the attendant rapid increase in crossing accidents has concentrated the attention of

the public more and more upon the grade crossing. In the summer months scarcely a day passes but the state papers carry on account of one or more such accidents with the attendant record of casualties, suffering and financial loss. Gradually the average citizen has come to realize that the only sure way to prevent a recurrence of the tragedies is to get rid of the crossings. While perhaps highway and railroad officials appreciate more fully the problems of this work, the public thinks more often in terms of the results it wants accomplished, and, as a rule, is willing to leave to its engineering representatives the problem of working out the solution. This attitude was well exemplified in Wisconsin when the last legislature almost unanimously passed a bill setting aside $100,000 to assist in financing the public's share of grade crossing work on the state trunk highway system.

The railroads officials can see that they are confronted by hostile public opinion that demands the elimination of all grade crossings. In some states the public utility commission or the legislature has laid down fixed percentages of apportionment, many on the basis of an equal division of the cost of the bridge and approaches. This plan is not applicable to highway relocation made to divert motor traffic from the grade crossings and while it can be applied to separation projects many of the improvements of this type are combined with changes in the location of the highway which cause increased construction expense to the public. In general, the railroad officials believe that many of the apportionments are unfair to their companies, and while they accept the ones forced upon them, there is little enthusiasm on their part and operations are confined to comparatively few crossings. As the larger railroads have thousands of grade crossings, with more being opened every day, it is not at all surprising that their officials hesitate to embark on a comprehensive plan for crossing elimination which they feel might mean bankruptcy to their railroad if carried to its ultimate completion.

Demands of the Railroads.—Leaving out of consideration for the present the various minor factors that arise in the individual cases, the major demands of the railroads may be summed up as follows:

1. A reduction in the railroad's share of the cost to 25 per cent, which they consider a reasonable figure.

2. The closing of the maximum number of grade crossings.

The railway engineers have given this question careful and serious thought, both as individuals and through the medium of their engineering organizations, and different solutions have been proposed. Some feel that the federal aid highway act should be amended so that a specific allotment would be made to each state for grade separations, the cost of this work to be divided 50 per cent federal money, 25 per cent state money, and 25 per cent of the total to be paid by the railroad company. While it was clearly the purpose of Congress to aid in the removal of the grade crossing hazard, there is nothing in the law to indicate that this phase of the work was to take precedence over the construction of a surfaced and maintained highway system. Since the passage of the federal aid act and before, the grade crossing problem has been given serious consideration by the state departments, but the highway engineer faced by a public clamor for more and more hard surfaced roads, from necessity has been forced to use the public funds for that purpose, and, as a result, has until recently accepted only such crossing improvements as could be built at a relatively low cost. While the public is now insistent in its demand for the elimination of the grade crossing, this group of highway officials will no doubt agree that the construction of the federal system has not yet reached that stage of completion where the proposed amendment would find support in Congress for some time to come.

The second requirement presents a serious problem. The highway transportation system, owned and operated by the public, comprises some 2,862,197 miles of roads, of which perhaps 200,000 represents state or federal trunks.

The closing of Town Road Crossings.—It has been suggested that the highway system should be properly correlated between trunk and feeder lines, the unnecessary branches being lopped off wherever their economic necessity cannot be shown, this work to be delegated to a properly qualified state authority functioning through state utility commissions who, in turn, should be required to work through a national authority associated with the Interstate Commerce Commission with respect to public policy in the production of safe and convenient highway transportation. Such a plan, if it could be put into effect, would permit the closing of many town road crossings, but many of the retirements would involve the inherent right of individual property owners of access to a public highway, and if many existing crossings were closed very considerable sums would be necessary to build the connecting roads. Just where these public funds would come from is not clear. While the Interstate Commerce Commission controls both the receipts and the disbursements of the railroads, it is not probable that they would display very much enthusiasm over the plan proposed, and it is questionable whether Congress would feel that public opinion would support such a change. In fact, the tendency is in just the other direction and without a doubt a few more years will see all the states in complete control of the main roads, the counties controlling the subsidiary trunks, and the local township handling its own problems in their entirety. Some of the states have laws which have made possible a reduction in the number of grade crossings over a period of years but in those states with large areas of developing country this is very difficult. There is no doubt that in many states laws should be passed which would more fully support the utility commission and make the closing of existing crossings easier and the opening of new ones more difficult, and to accomplish this very highway department should give its support.

Costs Apportioned in Proportion to Benefits.—There is one point and perhaps only one upon which the officials of both sides agree, and that is that the opportionment of cost of grade crossing improvements shall be in proportion to the benefits received by each. To the speaker's knowledge, however, no generally accepted method of determining these benefits has ever been developed, and in practice, each case is considered separately as it comes up with the ever-recurring arguments over the alleged benefits to each. No matter how carefully the plan of determining the benefits is reduced to a mathematical basis, assumptions must be made at the starting point, and it is over these assumptions that the arguments begin.

At the end of 15 or 20 years of what may be termed experimentation that have elapsed during the development of the motor vehicle, there are few states and few railroads that have a program for the future in grade crossing work. With most of the cheaper relocations and separations complete on the state roads, the time has come when a solution of the greater problem that now confronts us must be developed. With the rapid increase in the number of automobiles, the concentration of tremendous sums of money for highway improvement, and an irresistible demand on the part of the public for the elimination of grade crossings, it is the contention of the Wisconsin department that the problem is squarely before the management of the railroads and that they must provide for its solution in their underlying financial structure and not from operating revenue alone. A large part of the crossing accidents occur at rural crossings on the state system of highways and with the track elevation work in the larger cities must come the grade separations on the state roads as they carry the larger volume of traffic. These separations will come first and if a satisfactory and equitable method of procedure can be developed, no doubt it will be followed by the utility commissions and public officials handling town, village and city crossings as they come up in the future. Whatever the solution is to be, it must be worked out in a comprehensive way for without a

doubt the next ten years will see the public demanding and securing the separation of a large part of the crossings on the main high speed trunk lines, with automatic protection for the few that must remain.

Each State Will Have to Work Out Its Own Solution.—The existing federal statutes provide no method of procedure or plan or apportionment for grade crossing improvements, and with the wide variation of the laws on the subject in the various states it is obvious that under the existing conditions each one will have to work out its own solution. At the end of 15 years of endless argument and litigation, with traffic diverted from only 193 crossings on the state trunk highway system in that time, at a cost to the railroads of about $1,480 per crossing and with the more expensive separations to come, the Wisconsin department decided that the grade crossing problem was fast becoming an example of the irresistible force and the immovable body.

A careful study of the situation seemed to indicate that several essential elements were lacking in the general method of procedure employed. While the positions assumed by the parties at interest were diametrically opposite, it was felt that the problem was probably no more difficult of solution than many others encountered in the administration of the highway laws if the situation were approached by both sides with the idea of sincere co-operation.

As we grow older, we realize that a little of the spirit of the Golden Rule applied to our dealings with other men helps to smooth out many of the rough spots and at times makes possible the accomplishment of what has been deemed impossible. It is believed that all too frequently the policy of our department has been to decide what is to be done and then to advise the railroad company of the decision and notify them of the amount to be paid. The railroad engineers are intensely interested in the grade crossing problem and it is felt that they should be called in at the beginning and their advice and counsel secured in working out the plan of procedure.

Cooperation Arrangement With Railroads.—In the second place, there seemed to be no accepted plan of procedure or method of cost apportionment that could be applied to the average case in attempting to arrive at the final apportionment of cost. As a result, each new problem as it came up resolved itself into a struggle to balance assets and liabilities on each side, and the result was gamble. The Wisconsin group decided that the 15 years of experience had convinced them that the method commonly employed of attempting to agree upon the benefits to the two parties in each case had not proven wholly successful, and that a much better solution of the difficulty seemed to be to agree with the railroad officials, if possible, upon the percentages to be applied to the average case, these same percentages then to be applied to all cases, a uniform result being produced by the law of averages. It was felt that if the plan could be put into tangible form the problem would work out through the cooperation of the railroad officials, and to that end a conference was called at the office of the Wisconsin Highway Commission of chief engineers of the principal railroads operating in the state.

At this conference, the Railroad Commission was represented as well as the railroads. When the group assembled they were told that the Wisconsin department felt that $1,000,000 per year expended to cover the increased cost of work of this character would remove the larger part of the 758 crossings still remaining on the state trunk highway system in a ten year period, and their cooperation was asked in the necessary work. Feeling that there is a well concerted demand for the immediate removal of the grade crossing hazard and that the problem before responsible officials is not so much to determine who shall pay the last dollar of the bill as to develop some method which will produce results, the following plan of procedure was presented.

The arrangement, as worked out, is cooperative to the extent permitted by the statutory allotment of highway funds. The crossings to be improved are selected, if possible, after conference with railroad officials and the plan of approach developed jointly with them and with the engineers of the Railroad Commission. It is believed that this method will prove helpful in interesting railroad engineers in the problems of the highway organization. Compromises, of course, are necessary, both in the location of improvements and in methods of procedure, but both parties are working toward the same general result.

Procedure of the Wisconsin Plan.—In the financial plan presented it was agreed by the highway engineers that if the crossing hazard did not demand attention, the public would have to pay for the construction of the road in the existing location with the exception of that portion of it on the railroad right of way, the cost of which is assesable against the company by statute. It is felt that the railroads should only be asked to participate in that portion of the cost of the improvement which is made necessary by the effort to avoid the crossing hazard.

Surveys are made and estimates prepared for the proposed relocation or separation, as the case may be, and also for the improvement to the same standard of the existing road which crosses the railroad at grade. Where separation structures, or extremely heavy grading, or right of way costs on relocations are involved, it is obvious that it will cost more to build the new road than to improve the old one at grade. The costs are determined between points common to both old road and new, and the difference between these two quantities is termed the increased cost. Many railroads, however, cross the highways in a diagonal direction and it often develops that a road can be built along the track between two crossings with a material shortening in distance and, consequently, at a reduced cost. In such cases there is no increased cost and the railroad is not asked to participate. It is thought that the increased cost caused by the presence of the track is a better measure of the financial responsibility of the railroad than any plan heretofore developed. In those special cases where a separation structure is required on a highway newly opened, with no existing road handling the traffic, or where there is an existing structure that must be widened or altered to accommodate a modern highway, the total cost of the bridge and approaches or of the altering is used as the apportionable item.

Field inspections are made of each situation by railroad engineers accompanied by a representative of the Highway Commission, and, if possible, a plan of procedure decided upon at that time. It has been found that is is more satisfactory for the railroad to handle the design and construction of structures that are to carry their own traffic, the Commission to do the same with structures to carry the highway over the railroad. All work, both railroad company and highway, is done by contract, if possible, an exception being necessary, of course, with projects involving lowering or raising tracks, construction of false work, placing of girders, or rebuilding existing railroad bridges.

The matter is presented to the railroad company in a formal way by giving them a layout plan which shows all the factors of interest to both parties. This is accompanied by a preliminary statement of cost apportionment which assembles the work of both groups of engineers and shows what the probable apportionment of cost will be. If this seems satisfactory, an agreement is drawn up between the railroad company and the Commission, which is later submitted to the Railroad Commission for approval. No fixed sums are used in this agreement except in those cases where the railroad company does work with company forces. When the railroad force account work exceeds $10,000 or $15,000, the quantities to appear as part of the apportionable cost are agreed upon each day and the fixed sum method is not employed. Payments are based on measured quantities and contract unit prices, each party having the privilege of checking the work of the other, all books of record being open to both parties. The quantities on the new route can, of course, be determined as

the work progresses, but to avoid dispute the quantities on the old road are taken from the preliminary estimate above referred to and inserted in the agreement. The unit prices to be used in determining the deductible old road cost are the same as for the new road constructed. At the time of settlement, the estimate is set up on the basis of final agreed measured quantities and contract unit prices, and payment made by one party to the other to bring about the agreed result.

With the firm conviction that the interests of the public require the removal of the grade crossings as rapidly as possible and on the agreement of the railroad companies to waive their many objections and to provide funds for a well defined program of improvements, it has been decided, for the time being, to apportion the item of increased cost 40 per cent to the railroad company and 60 per cent to the state.

One Year's Operation Under the Plan.—This plan has been in operation for a full construction season and with the exception of one Class A railroad the officials are co-operating to the fullest extent. In the earlier years of the good roads movement, grades were separate and highways relocated to avoid crossings only at those points where the expenditures would not be heavy. During the period of prosperity immediately following the war, it was possible to attack a few of the more expensive separations but, as a rule, they were avoided. All of the railroads of Wisconsin are primarily grain-carrying roads and during the years of poor crops and agricultural depression the companies have resisted proposals that involved any considerable sum of money, for they felt that the railroads would be forced to assume a share of the cost that they did not think was fair. It is interesting to note that in the period from 1915 to 1925, state trunk highway traffic in Wisconsin was diverted from 193 grade crossings. This was accomplished by constructing 15 separation structures and relocating the highways so that 37 crossings were closed, the remainder being avoided. The railroad companies contributed about $100,000 toward the portion of this work that included separation structures and $176,000 toward the cost of the highway relocations to divert traffic from the crossings. In addition, $12,000 of railroad money was used to assist in the reconstruction of existing bridges to make them satisfactory for motor traffic. In all, $288,000 was furnished by the railroads in this 10-year period, or an average of $1,500 per crossing.

The 1926 construction season was entered with agreements in effect that in the end netted the public $3,200 for the 18 crossings included in that year's program, or $177 per crossing. Faced with the ultimate construction of hundreds of expensive separations and relocations, it seemed obvious that some method of procedure had to be worked out that would take the motor traffic off the crossings at a more rapid rate and with the co-operation of the railroad officials, if possible.

The plan as outlined in this paper was entered into in the fall of 1926, and while it is not all-inclusive, it does offer a solution and a definite plan of procedure to be applied to the individual cases as they come up where grades are separated or a major portion of the motor traffic is diverted from the crossings. While the Wisconsin statutes are so written that the crossings must be taken up in connection with road construction projects as they arise and the department has little direct authority in the location of these projects, the recent legislature provided $100,000 for grade crossing work, to be located at the option of the Highway Commission, and several difficult and expensive separation can be carried out each year at locations satisfactory to the Highway Commission and the railroad companies. Due to the fact that it is very difficult under the Wisconsin laws to close a grade crossing if private interests are involved, the railroads were asked to waive their objections to the retention of the crossing at grade if a major portion of the traffice were removed. It is now generally conceded that the liability of accident at a grade crossing is dependent upon the number of trains and motor vehicles combined and while the rail traffic may be light on some lines, the companies have been asked to consider their state trunk highway crossing problem as a unit, each crossing avoided for state trunk highway traffic being one step nearer the final objective. The increased cost plan practically eliminates the objection of the railroad engineers to participation in the cost of road work adjacent to the structures for the same safety standards are applied to the old road as to the new and any extra cost is obviously brought about by the presence of the track and the effort to eliminate the crossing. With the existing statutes requiring railroads to assist in improvements of this character, it necessarily follows that the railroad must be considered as the cause of the extra expense and the increased cost of the road work caused by the presence of the track becomes the logical basis of apportionment. This plan is not perfect by any means. In fact, it has very definite limitations, but it does seem to offer an equitable method of procedure and one to which the railroad companies are willing to subscribe and set up funds for a definite grade crossing program.

What Has Been Done Under the Plan.—Under the plan and with the co-operation instead of the objection, resistance and refusal of the railroad engineers, traffic was taken from 37 state trunk highway crossings in 1927 at a cost to the railroads of $74,500. The increased cost of this work over that of building the old road at grade was about $242,000. Five separation structures were involved, the remaining expenditures being in connection with relocation of the highway to divert traffic. These projects were opened to travel and other jobs are under way which will be partially financed with $97,000 of railroad money and additional agreements are in effect under which the railroads will pay $45,300. In the last year the railroads have agreed to pay $217,200, or about 75 per cent of the total amount secured in the ten years preceding, after endless arguments, litigation and delay. There is also a Railroad Commission order outstanding assessing $80,000 against one railroad. In addition to the $142,00 under agreement and the $80,000 provided by the Railroad Commission, the Highway Commission will ask the railroads for at least $275,000 for other improvements to be built in 1928, and we believe it will be furnished by the companies. This, of course, involves several expensive separations and it is felt at this time that well over a million and a quarter dollars will be expended next summer in the elimination of 52 crossing on the state trunk highway system of Wisconsin.

World Congress of Engineers

The program of the World Congress of Engineers, to be held in Tokio next year, was outlined recently in a cablegram received by Maurice Holland, executive secretary of the American Committee of the Congress, 29 West 39th St., New York City, from Baron C. Shiba, vice-president of the Congress.

The meeting, Baron Shiba stated, will convene in Tokio on Oct. 30, 1929. The official languages of the Congress will be English and Japanese. The first week, the cablegram stated, would be devoted to technical papers and social meetings, the second week to inspection trips in Tokio and the vicinity and the next fortnight to trips throughout Japan especially arranged to give the delegates an opportunity to visit the great industrial and engineering centers of the country.

The World Congress, which will be attended by engineers and scientists from all parts of the world, is aimed at the promotion of international co-operation in the study of engineering science and problems. International authorities on engineering are being requested to prepare papers on subjects of interest and moment to engineers. It will be the first meeting of its kind ever held.

A notable list of American engineers will attend the Congress, 80 of the nation's foremost engineers and scientists having accepted membership on the American Committee under the honorary chairmanship of Secretary Hoover and the active chairmanship of Dr. Elmer A. Sperry.

Hauling With Large Tractor Drawn Wagons in Power Shovel Operation

Use of Large Dump Wagons in Grading for Highways

By T. WARREN ALLEN AND ANDREW P. ANDERSON

Large dump wagons drawn by crawler-type tractors have recently come into considerable use with power shovels. An interesting discussion of the operation of these tractor-wagon combinations is given in the April issue of Public Roads, the official publication of the U. S. Bureau of Public Roads. The matter on this particular subject is a part of a series of articles now running in the above mentioned publication, on power shovel operation in highway grading. These articles are a report of observations made on going projects by the Division of Management of the U. S. Bureau of Public Roads. The authors of the article are T. Warren Allen, Chief Division of Management and Andrew P. Anderson, Associate Highway Engineer. We are quoting below the section relating to the use of the tractor-drawn wagon outfit.

Bringing a Large Capacity Dump Wagon Into Position Under the Dipper

Tractors Hauling Large Capacity Dump Wagons in Heavy Going

THE merit of the tractor-wagon combination appears to be due to the following facts: (1) The crawler-type tractor can be operated effectively over a wide range of road conditions such as are found in grading work; (2) it can be maneuvered readily on steep grades, over rough or soft ground and among stumps, rocks, and other obstructions; (3) it can maintain a relatively high draw-bar pull under these conditions and can haul comparatively large loads; and (4) the wagons which have been studied were strongly constructed and well adapted to operate under severe field conditions and were equipped with a simple and effective dumping mechanism.

Under normal working conditions a heavy tractor can draw two of these dump wagons, each having a capacity of 5 or 6 cu. yd. If the haul is down very heavy grades, it is sometimes necessary to limit the train to one wagon because at present wagons are not equipped with brakes. Tables 1 to 5, inclusive, indicate that where ground conditions are fair and the road of sufficient width, two wagons can be handled almost as speedily as one, not only in the operations of dumping, turning, and maneuvering, but also in the direct haul. The use of two wagons is clearly an advantage if all loading is done at the rear of the shovel instead of the more logical method of loading the vehicles at the side. A one-wagon train can be backed with ease and dispatch, but to back a two-wagon train requires considerable skill and time. A partial solution of this difficulty might be found in the use of a larger shovel. The handicap of a long swing would still remain, but a smaller number of dippers would be required to load each train.

Turning and Dumping With Tractor Trains.—The various operations of turning, dumping, and maneuvering are comparatively fast in the hands of a skillful operator. The exact time for each of these operations is shown more fully in Tables 1 to 4. Tables 2 to 5 show the hauling speed for various lengths of haul and under the varying conditions on different jobs. These tables will indicate to some extent what can be expected from this type of equipment as well as the amount of the time losses most likely to be chargeable to its use.

Of the items which make up the time constant, it will be observed that the loading time is long. This is inevitable on account of the large amount of material carried per load. The loading

End Loading into Tractor Dump Wagon Combination

time is usually from 5 to 7 minutes for a train of two 5 yd. wagons. With a standard ¾ yd. shovel, from 7 to 10 dippers are required to load each wagon, and, if the shovel is working at a rate of three dipper loads per minute, from 2⅓ to 3⅓ minutes will be taken up in loading each wagon. If the cut is narrow so that the turning radius is short it may be necessary to use the shovel in getting the second wagon into loading position as on short turns it does not follow around perfectly. On wide roads this extra operation is not necessary, nor is it required in loading at the side of the shovel. Any conditions which extend the dipper cycle beyond 20 seconds—stiff clay, badly shot rock, stumps, etc.—will also extend the loading period so that digging conditions must be fairly good and ample turning space must be available if a 2 wagon train is to be loaded every six minutes with the ordinary ¾ yd. shovel.

At the dump, layer or end dumping can be used with almost equal facility. With ordinary materials the load as it is dumped is spread over a length of some 20 ft. In layer dumping these piles can be spread either by a heavy blade grader or by a bulldozer, and the material compacts without serious difficulty under the tractors and wagons as the work progresses. Where this practice is followed the dumping time is almost negligible as the train need hardly come to a full stop in order to make the dump. Dumping the load is often merely a part of the general operation of turning at the dump. Where end dumping is practiced, the loads are dropped in the same general way as the turn is being made and then a bulldozer or other equipment is used to push the dumped piles over the bank.

Turning is fast. Crawler-type tractors can usually work close to the edge of a fill, so that a train of two wagons can ordinarily be turned on a 25 ft. embankment without backing. Turning time at both the dump and the cut is therefore low, as shown in Tables 1 to 3. At the shovel the turning is usually done so quickly that the drive-in can be made within a normal dipper cycle. Under fair operating conditions the average time required for turning at the dump, dumping the load, and turning again at the shovel, should not exceed a total of one minute, and under adverse conditions should not exceed a total of 1½ minutes.

Productions Obtained.—The rate of travel of tractor trains is only a little greater than that of teams—from 275 to 325 ft. per minute under favorable conditions, and it may fall as low as 200 ft. per minute under adverse conditions. Because of this low speed and the wide distribution of the tractor load on the road, the cost and difficulty of maintaining a satisfactory roadway is seldom as great as is found necessary for the successful operation of heavy trucks. Trucks must normally obtain their production by maintaining a good rate of speed—8 to 10 miles an hour—when carrying a reasonable load. The tractor train obtains its production by taking out a large load at a low hauling speed but with little time loss in dumping and turning.

Dependability is, of course, an important item in selecting hauling equipment and is particularly so in the case of tractor trains as many outfits use only two or three units and the failure of one will reduce the output by 33 or 50 per cent. During the studies few delays were noted and these were very largely chargeable to carelessness or indifference on the part of the operators. From extended observation it is believed that only high-grade operators should be employed and systematic attention should be given to maintaining proper operation practices and to keeping the equipment in first-class condition.

Number of Hauling Units Used of Great Importance.—Use of a proper number of hauling units is of outstanding importance. A tractor and two 5 yd. wagons represents quite an investment. The operating cost per train is also high and is made up approximately as follows:

Driver	$ 7
Depreciation	13
Gasoline and oil	7
Repairs	3
Total	$30

A high output per unit is necessary to justify this expenditure. Obviously, the minimum hauling equipment which can maintain full shovel production is two trains. Under ordinary conditions two trains of two wagons each should be able to maintain full production for a ¾ yd. shovel up to a haul of 600 or 700 ft., depending on the exact rate of shovel operation. The minimum cost per day for a grading outfit provided with this equipment is about $135 (shovel, $50; two trains, $60; dump, $25). At a haul of about 700 or 800 ft. a third unit will be needed, and if there is much hauling beyond 1,600 or 1,800 ft. a fourth train may prove desirable. Tables 6 and 7 are developments of the same data as those given previously in connection with the discussion of team and truck hauling.

Getting Large Dump Wagon in Position for Loading

They show how the total cost of the job is affected by using various numbers of 1-wagon and 2-wagon tractor trains. It will be noted that the use of 1-wagon trains is much more expensive than 2-wagon trains except for hauls less than about 400 ft. Using this method of analysis and the prices investigation and experience indicate for the particular job, the contractor can determine within reasonable limits not only what type of equipment is preferable but also the number of units which will prove most economical to place on the job.

Where 2-wagon trains are used, each additional hauling unit after the first two extends the limit to which full shovel production can be maintained considerably—under favorable operating conditions about 900 ft.—and if shovel operation is slow or difficult the distance may be much greater. The daily operating cost of each train is high and it is not always easy to decide just when an additional train would prove economical. Assume that two tractor trains of two wagons each can maintain full shovel production up to a haul of 600 ft., and that three trains could maintain full production up to a haul of 1,500 ft, and that the daily cost of operating with the two trains is $135 per day and that the additional train will cost $30 per day. An additional unit should be added at the point where increased production is proportional to the increased cost. In this case it should be added at the haul distance corresponding to the theoretical train requirement, N, as determined by equating the cost ratio to the production ratio, $\frac{135}{165} = \frac{2}{N}$, which results in the value, N=2.44 trains. The additional train requirement varies from 0 to 1 over a distance of 900 ft. and the thearetical requirement of 0.44 of a train will be at a distance of 396 ft. The additional 2-wagon train should therefore be added at a haul of approximately 1,000 ft.

Under the conditions prevailing on the jobs given in Tables 6 and 7 there is a decided advantage in using 2-wagon trains, particularly on the long-haul job in Table 7. No allowance has been made in the examples for the possible saving on short hauls where a portion of the equipment will not be needed. Some saving is possible in operating expense, even though drivers must be paid. Where horses and wagons are used, feeding the horses and the drivers when work is shut down generates an idle-time cost which is at least half of the operating cost. With tractors or trucks the machines can be protected to avoid depreciation costs; there is no charge for gasoline, oil, or repairs and the driver may be laid off if the shutdown for that unit is likely to be long. It seems to be practical to carry mechanical hauling equipment much more nearly in balance with the maximum length of haul than can be done where teams are used.

On the other hand, profits are seriously affected by using more tractors than are actually needed at any particular time. If two trains can haul all the material the shovel can dig and three are used, then the daily cost of operation is raised from $135 to $165. If full shovel production is at the rate of 720 cu. yd. per day, then with two trains working, the unit cost is 18¾ ct. per cublic yard, while with three trains working it will be 22-11/12 ct. per cubic yard, an increase of over 22 per cent.

The use of too few hauling units may affect profits even more than the use of too many. In the case given in Table 6 the most advantageous number of 2-wagon trains is two. The use of only one train would increase the cost of the job nearly $7,200, and the use of one train more than the proper number would increase the cost about $1,250. With 1-wagon trains, three is the most advantageous number, and if either two or four are used the cost is increased $3,225 and $733, respectively.

The advisability of laying off surplus units at any time depends entirely on the frequency with which haul distances fluctuate. Opportunities will exist to a considerable degree on some jobs, while on others they will be entirely absent. In making the calculations for any particular job these facts should be kept in mind and all possibilities utilized. On some of the jobs studied where 2-

Table I.—Time Constant Studies of Tractors, Each Drawing One 5 Yd. Steel Wagon. Loading Done by a ¾ Yd. Shovel

[Time constant, 219.1 seconds]

Dippers per load	Loading	Waiting at dump	Turning at dump	Dumping	Turning at shovel
Number	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*
6	152	.....	14	7	16
6	151	.....	11	9	10
7	166	.....	9	10	13
5	121	.....	12	9	13
7	177	.....	8	8	15
7	179	.....	9	8	15
7	185	.....	14	12	14
7	182	.....	19	15	14
7	174	.....	44	10	15
7	167	.....	14	7	16
8	209	.....	17	7	14
7	167	.....	15	10	11
7	180	14	22	10	14
8	188	.....	15	7	12
8	216	13	14	8	15
7	195	10	17	7	22
8	204	.....	17	9	14
8	182	.....	16	8	16
8	209	.....	15	9	17
7	175	.....	10	6	20
Av. 7.1	178	1.9	15.6	8.8	14.8

Table II.—Comparison of Operating Speed of Crawler Tractors Drawing 1-Wagon and 2-Wagon Trains

The wagons were 5-yard capacity and were loaded by a ¾-yard shovel. Operation in late fall and winter over roads in fair and poor condition]

Operation	Time for 1-wagon train [1]	Time for 2-wagon train [2]
	Seconds	*Seconds*
Loading	152.0	308.5
Waiting at dump	67.6	86.9
Turning at dump	20.9	22.6
Dumping load	17.4	20.7
Turning at shovel	25.0	17.5
Spotting second wagon		13.6
Total	312.9	469.6

[1] Results are the average for 153 round trips. Average round-trip speed on hauls from 300 to 2,000 feet was 300 feet per minute.

[2] Results are the average for 56 round trips. Average round-trip speed on hauls from 300 to 2,000 feet was 295 feet per minute.

Table III.—Typical Studies of Operation of Crawler Tractors Drawing Two 5 Yd. Wagons. Loading Done by ⅞ Yd. Shovels

Most of hauling over rough and rocky roads with steep grades

Haul	Loading	Hauling to dump	Turning at dump	Waits and delays	Dumping load	Returning to shovel	Turning at shovel	Speed loaded [1]	Speed empty [1]
Feet	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*
1,300	286	275	22	37	19	302	14	291	240
1,400	367	320	19	30	18	350	14	300	235
1,425	346	312	19	48	8	298	17	274	300
1,425	391	334	23	44	12	370	17	305	300
1,425	324	247	13	32	8	288	13	346	310
1,450	267	256	22	62	15	273	25	339	320
1,475	765	255	17	94	14	270	13	341	326
1,450	314	301	21	75	15	320	15	328	345
1,450	361	268	28	72	19	282	19	362	307
1,500	372	319	18	264	15	317	14	282	282
1,500	322	289	19	37	8	322	14	334	279
1,500	332	322	19	82	10	320	14	279	261
1,500	263	296	17	48	10	312	14	322	305
1,525	340	293	18	48	16	299	14	341	305
1,550	277	282	15	92	14	302	16	316	330
1,550	288	319	16	74	28	319	16	292	291
1,600	305	330	20	45	21	321	15	298	318
1,650	296	306	19	34	17	326	6	328	323
1,650	330	372	21	85	10	330	13	306	283
1,650	322	339	21	36	25	304	16	376	372
Total 39,825	6,694	5,746	396	1,263	340	8,134	376	.....	.....
Av.... 1,491	305	267	18.1	63	17	397	19	311	302

Short hauls over rough and rocky ground. Shovel operating in frozen ground

332	344	195	25	21	24	175	28	200	120
330	366	163	24	646	22	182	29	195	111
375	422	122	26	112	18	161	29	185	124
375	727	189	29	13	26	184	26	172	122
400	375	124	31	46	23	190	39	193	126
400	491	113	19	14	23	193	28	212	126
425	365	116	28	24	15	176	40	220	130
450	403	118	26	5	26	217	35	229	135
450	391	145	33	9	20	173	28	207	174
450	511	188	23	9	30	213	28	212	158
Total. 4,173	4,619	1,551	263	907	234	1,677	304	.....	.....
Av..... 417	462	123	26	91	23	168	30	204	132

Hauling over road in fair to poor condition with steep grades

875	397	193	22	.....	7	229	19	270	[illegible]
900	393	207	30	30	11	196	12	261	272
950	273	215	13	40	10	205	15	279	283
950	383	207	23	63	5	204	13	252	264
1,000	296	186	17	.....	24	207	11	232	240
1,050	312	208	24	80	10	214	13	252	254
1,100	306	214	22	.....	13	228	12	265	269
1,150	385	208	26	.....	11	252	22	249	274
1,200	233	242	18	.....	14	241	10	257	256
1,250	301	250	22	.....	19	257	9	260	262
1,300	330	268	28	32	18	304	12	268	258
1,350	322	273	27	109	28	321	27	265	293
1,375	360	275	29	143	25	301	19	280	274
1,400	347	277	26	99	21	317	23	268	283
2,000	294	318	30	.....	20	412	26	238	280
2,000	305	331	33	50	20	410	11	236	280
2,050	314	357	29	90	25	425	17	243	280
2,100	373	356	27	43	28	443	21	232	284
2,100	457	329	25	103	28	441	18	246	290
2,150	400	363	34	39	29	433	13	250	301
2,150	290	431	17	35	28	443	11	300	293
2,200	323	405	30	34	24	419	12	307	300
2,200	293	435	21	177	24	466	20	310	292
2,250	303	416	22	76	13	433	10	324	307
2,300	370	435	26	179	24	458	19	325	301
Total. 38,400	6,643	7,511	507	1,539	542	8,240	401	.....	.....
Av.... 1,676	321.7	300.2	22.6	61.5	21.7	329.9	16	315	286

[1] On both jobs the haul was down a grade resulting in a higher speed while loaded than while empty.

Table IV.—Hauling Speed of Tractors with One 5 Yd. Wagon with Road Conditions Varying from Good to Very Poor with Deep Mud

Round trips timed	Distance	Haul to dump	Speed loaded	Return to shovel	Speed empty
Number	*Feet*	*Seconds*	*Feet per minute*	*Seconds*	*Feet per minute*
6	475	116.0	246	153.0	196
9	550	137.0	241	161.0	205
8	300	73.0	247	83.0	217
8	390	87.5	268	96.0	244
6	510	107.7	284	118.3	258
2	700	138.7	303	136.7	206
6	375	104.5	215	134.1	167
2	550	118.0	290	130.0	254
16	90	46.4	148	42.8	164
10	740	199.2	223	148.7	298
7	1,050	241.7	260	207.3	303
5	1,025	202.2	305	184.0	334
8	785	215.7	219	142.1	331
Total. 86	47,215	11,331.4	.....	11,182.2	.....
Average.....	.....	.....	240	.....	253

Table V.—Hauling Speed of Crawler Tractors with One 5 Yd. Wagon with Road Conditions as Noted

Dippers per load	Length of haul	Time		Average speed		Remarks
		Haul	Return	Haul	Return	
Number	*Feet*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*	
6	300	73	80	247	203	
6	300	80	74	300	243	Haul down 6 per cent grade with mud hub deep.
6	300	65	76	277	237	
6	300	64	74	281	243	
9	310	82	83	239	214	
6	300	72	82	280	196	
7	350	77	84	198	195	Muddy, grade light.
6	300	69	64	174	196	
8	320	74	85	162	165	
7	300	79	82	152	194	
7	150	51	57	177	158	Road good, easy grades; more trains on job than needed.
7	150	52	53	172	177	
7	150	47	61	192	145	
8	150	52	57	173	158	
8	[1] 50	28	36	79	83	
8	[1] 50	43	46	70	65	Road good, easy grades.
7	[1] 50	37	42	81	72	
8	[1] 50	40	39	75	77	
7	575	140	213	280	140	Mud hub deep.
7	575	185	200	223	185	
F. 7	4,300	1,308	1,351	236	209	

[1] Not included in averages.

wagon trains were used, the trains were reduced to 1-wagon on the shorter hauls. The net operating cost remained nearly as high as before.

Operating Conditions.—Where tractor trains are used for hauling, the direct cost of keeping the oufit idle is so low that there is more danger of operating too soon after rain than there is of delaying too long. When idle the tractor trains as well as the shovel generate practically no cost except interest which is a relatively small factor as compared with the total daily operating cost. When working, each train costs about $30 a day. Full-time men about the shovel and general job overhead generate a cost not far from $40 a day. If three trains are normally required in order to maintain production, the daily cost of operating is about $165. Under such conditions (providing no penalties are involved) a yardage of nearly three-fourths of that required to pay the cost of normal production is necessary in order to justify working at all.

There is no great danger that working too soon after rains will create road conditions likely to interfere with the work for some days. Road conditions must be such that they would be considered bad for most types of hauling equipment before the rate of operation of tractor trains is much affected. How soon work shall begin after a storm is, in general, dependent on the conditions at the pump and at the shovel rather than on the condition of the roadway. The fact that this type of hauling equipment can operate successfully where hauling conditions are below normal does not mean that attention to the roadway can safely be neglected. The increased cost of fuel and the wear and tear on the equipment on a bad road is naturally much greater than on a good road. If the job is to be made to yield a satisfactory profit, high-grade management is perhaps even more necessary where tractors and heavy wagons are employed than where ordinary team hauling is used.

Highway Safety Pageant

National distribution of a dramatic pageant for production in schools and churches of the United States has been started by the American Road Builders' Association. The pageant, written by F. A. Boggess, high school principal of Boulder, Colo., won first prize in a national competition for the best idea on highway safety.

The pageant, together with complete instructions for production, will be furnished gratis by the Road Builders' Association to all schools and churches interested in highway safety. It has been selected by nationally known judges as the best available plan for the safety education of young people.

The pageant was selected as the winner of a $500 cash prize from among hundreds of manuscripts submitted by contestants in every section of North America. Ten prizes in all were awarded and totalled $1,000. The second award was made to Barry Mulligan, Washington, D. C. Other prize winners were Albert Mahlen, New York City; Dr. A. E. Knoefel, Black Mountain, N. C.; Thos. F. Power, Worcester, Mass.; Albert C. Rose, Chevy Chase, Md.; Frank G. Duck, New York, N. Y.; Rev. Clyde Anthony, Kalamazoo, Mich.; Jas. H. Brown, Battle Creek, Mich.; Edward F. Carson, Brooklyn, N. Y.

Table VI.—Analysis to Determine the Most Economical Number of Tractor Trains for Use on a Given Job

Quantities	Haul	Days work at full shovel production	Number of 2-wagon tractor trains [1]				Number of 1-wagon tractor trains [2]				
			Number required to maintain full shovel production	1	2	3	Number required to maintain full shovel production	2	3	4	5
				Days required				Days required			
Cubic yards	*Feet*										
14,400	500	20	1.9	38.0	20.0	20.0	2.6	26.1	20.0	20.0	20.0
10,800	600	15	2.0	30.0	15.0	15.0	2.8	21.2	15.0	15.0	15.0
7,200	700	10	2.1	21.1	10.6	10.0	3.1	15.3	10.2	10.0	10.0
10,800	800	15	2.2	33.3	16.7	15.0	3.3	24.6	16.4	15.0	15.0
5,760	900	8	2.3	18.7	9.3	8.0	3.5	14.0	9.5	8.0	8.0
7,200	1,100	10	2.6	25.6	12.8	10.0	4.0	19.7	13.2	10.0	10.0
10,800	1,200	15	2.7	40.0	20.0	15.0	4.2	31.2	20.8	15.6	15.0
Total	66,960	93		202.7	104.4	93.0		152.1	105.1	93.6	93.0
Cost per day				$105	$135	$165		$129	$156	$183	$210
Cost to complete job				21,284	14,094	15,345		19,621	16,398	17,129	19,530

[1] Tractors drawing two 5-cubic yard steel wagons, $30 per day, speed 300 feet per minute, loading time 6 minutes per train, and total time constant 8 minutes.
[2] Tractors drawing one 5-cubic yard steel wagon, $27 per day, speed 300 feet per minute, loading time 3 minutes, total time constant 4½ minutes.

Table VII.—Analysis to Determine the Most Economical Number of Units for Use on a Given Job with Considerable Variation in Haul Distance

Quantities	Haul	Days work at full shovel production	Number of 2-wagon tractor trains [1]						Number of 1-wagon tractor trains [2]						
			Number required to maintain full shovel production	2	3	4	5	6	Number required to maintain full shovel production	3	4	5	6	7	8
				Days required						Days required					
Cubic yards	*Feet*														
7,200	300	10	1.9	10.0	10.0	10.0	10.0	10.0	2.6	10.0	10.0	10.0	10.0	10.0	10.0
18,720	600	26	2.0	26.0	26.0	26.0	26.0	26.0	2.8	26.0	26.0	26.0	26.0	26.0	26.0
14,400	900	20	2.3	23.3	20.0	20.0	20.0	20.0	3.5	23.3	20.0	20.0	20.0	20.0	20.0
10,800	1,200	15	2.7	20.0	15.0	15.0	15.0	15.0	4.2	20.8	15.6	15.0	15.0	15.0	15.0
5,760	1,500	8	3.0	12.0	8.0	8.0	8.0	8.0	4.8	12.9	9.7	8.0	8.0	8.0	8.0
10,080	1,800	14	3.3	23.3	15.6	14.0	14.0	14.0	5.5	26.1	19.3	15.4	14.0	14.0	14.0
7,200	2,400	10	4.0	20.0	13.3	10.0	10.0	10.0	6.8	22.8	17.1	13.7	11.4	10.0	10.0
7,200	3,000	10	4.7	23.3	15.6	11.7	10.0	10.0	8.1	27.2	20.4	16.3	13.6	11.7	10.2
14,400	4,000	20	5.8	57.8	38.5	28.9	23.1	20.0	10.4	69.3	51.9	41.6	34.6	29.6	26.0
10,800	4,600	15	6.4	48.3	32.2	24.2	19.3	16.1	11.5	58.6	44.0	35.2	29.3	25.1	22.0
Total, 106,560		148		264.0	194.2	167.8	155.4	149.1		297.0	234.0	201.2	181.9	169.4	161.2
Cost per day				$135	$165	$195	$225	$255		$156	$183	$210	$237	$264	$291
Total cost of job				35,640	32,043	32,721	34,965	38,081		46,332	42,822	42,252	43,110	44,722	46,900

[1] Tractor to draw two 5-cubic yard steel wagons, $30 per day, speed 300 feet per minute, loading time 6 minutes, total time constant 8 minutes.
[2] Tractors drawing one 5-cubic yard steel wagon, $27 per day, speed 300 feet per minute, loading time 3 minutes, total time constant 4½ minutes.

The Use of Timber for Secondary Highway Bridges

A Study of Short Life Structures Under Michigan Conditions

By C. A. MELICK
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The rapid changes in the status of many of our township highways from obscure, narrow, dirt roads to important improved county and state highways and the corresponding continual changes in the majority of our county and state roads, transforming these into roads of still higher type, plainly indicate the necessity of planning with great foresight and care the replacements, alteration, and maintenance of existing bridges on all highways lest our investment be unwisely made if not absolutely squandered. The same warning may also be considered to apply to bridges over streams which are apt to be dredged within the next twenty years or on which navigation interests are apt to be developed.

The Changing Status of a Road.—A so-called permanent type of bridge should, in general, be good for 50 years of service in order to justify its cost. What man among us would today care to make a positive assertion that the status of a road or drainage project would be adequate for even a 5-year period? In the face of such indefinite tenure of life, what can the bridge engineer do to insure not only against total loss but also to guarantee a sound investment of the public funds? There appears to be two plans, either of which may be chosen: Either to build a permanent type of bridge which can be widened in the future or to adopt a less expensive type which can be economically scrapped after serving a reasonably short period of time. An uncertainty of prediction of greater life than five years might lead one to assume that untreated timber, which has a life of from five to ten years, should in the latter case be chosen, but we should always remember that it may be desirable to retain the bridges for fifteen, twenty or more years, as our guess at conditions may be very badly off and it would generally be unwise not to use creosoted timbers for exposed portions of such bridges, this material having a life of around thirty or more years.

In the case of a stream where no dredging of any consequence may be anticipated as determined from the nature of the stream itself, as well as from the drainage conditions within its watershed, and where the necessary funds for construction are available, structures of a permanent nature may and generally should be placed provided that the design of the structure shall be such that the structure may be widened for additional roadway or sidewalk provisions without the loss of any of the fundamental investment when such widening shall be made. This is the present policy of the state highway department and the successful working out of this plan will be a source of increasing satisfaction to our successors in the handling of bridge problems as well as to the public, whose safety, convenience and pocketbook are affected and conserved.

When to Consider Less Permanent Type.—For all other conditions than the above, i. e., when dredging is probable or when funds are inadequate or when the type of road development is liable to undergo radical changes, it is highly desirable that we consider and develop a cheaper and less permanent type of structure which will be entirely adequate for at least present legal loadings, with a reasonably small margin for increased loadings either in the loadings themselves or in the unit stresses used, and which will provide roadway and walk widths not greatly in excess of the present traffic requirements or those immediately contemplated. Such structures should also very greatly be governed by the suitability of the structure to its surroundings as well as to the funds available.

This leads us to consider the vitally fundamental question as to what minimum relative saving in cost, under that necessary for a permanent type, will justify the adoption of a cheaper or less permanent or otherwise less desirable type of structure.

Relative Life and Costs.—If we assume that the cost of a permanent type of bridge of given roadway and walk facilities, built with provision for future widening is Co and the cost of a cheaper structure with the same facilities but without necessarily provisions or desires for future widening is C1, the initial or first cost saving is Co—C1, which may be designated as S. We may further assume C2 as the cost of future widening of the permanent structure for ultimate facilities and C3 as the cost of providing at the end of t years a complete new structure of permanent type with the ultimate facilities. V may represent the salvage value of the temproray or cheaper structure when discarded for the permanent structure. i. e., salvage value less cost of removal, and p may represent the rate of interest. Then we may assume that the relation [S(1+p) to the power t]+V=Co will give a guaranteed no loss investment, actually giving a brand new job at the end of t years in the event that the passage of time shall disclose that the original facilities are still adequate.

This relation assumes also that the original "permanent" structure is at least permanent enough to have a life of T years where T is obtained from the expression (1+p) to the power T = [1+(C3—C2) divided by C1] X [[(1+p) to the power t] — 1] or [1+(Co divided by C1] × [[(1+p) to the power t] — 1] as the case may be, this being derived from simply equating the annual charges, omitting maintenance charges, and considering as an annuity. If widening is found necessary at that time, we may assume [S(1+p) to the power t] + V = C3 — C2. If p = 5 per cent and V be assumed as zero, its minimum probable value (S divided by Co) or (S divided by C3 — C2) as the case may be = [1 divided by (1+p) to the power t] and for values of this saving ratio of 15, 20, 30, 40, 50, 60, 70 and 80 per cent the required corresponding term of years before replacement to insure no loss and a new permanent structure are 39, 33, 25, 19, 14, 10, 7½ and 4½ years respectively.

In locations where traffic is not heavy and adjacent axles of vehicles using the highway and having nearly equal weights of maximum legal capacity are infrequent and where timber or temporary floor surfacing is used, it may be assumed that the H 12½ loading of our specifications is practically the equivalent of our present statutes. When concrete or equivalent surfacing is used, it is not wise to consider less than our standard H 15 specification loading, which is just 6/5 of the H 12½ loading. Impact can not be overlooked in designing such structures and the use of a smaller value than our standard specification ratio, which has a maximum value of 30 per cent, is not justified.

The distribution of loads is a mechanical matter and we can not justify any concessions in this regard. The unit stresses for temporary jobs have inherently our only provision for the future increase of traffic and the structures of short life we are justified in a reasonable increase of unit stresses. However, in the case of structural steel members, it is well to so design these members that they may at the salvage

period be utilized in the new structure, in which case the unit stress should not be increased. With this general understanding, a study will be made of the various types and economy and desirability of cheaper structures for temporary or short life structures as well as for a cheaper type of permanent structure which sometimes warrants consideration.

The Timber Pile Trestle.—The simplest and cheapest type of structure is the timber pile trestle with timber stringers and backwall and with single transverse plank floor. Even with this elementary type, the question as to advisability of creosoting or protecting a part or all of such timbers must be considered. Creosoting usually adds about $30 per M feet board measure in place or about 50 cts. per lineal foot for piling based on a 12-lb. full cell treatment. Creosoting of surfacing plank need not be considered as such plank will, if of good material, wear out rather than rot out, but sub plank should always be treated as in such cases the base plank will be expected to outlast at least two and probably three surface coats.

We may, in general, discuss this study in the order of the type of construction proposed for railings, wearing surfaces, floors, superstructure, piers, abutments, and backwalls. Timbers used may be classified as railing posts, rail braces, rails, surface plank, base plank, stringers, caps, posts, sills, braces, walers, girts, piles, cribs and backwall plank. When timber is specified for Michigan use, Douglas Fir or Long Leaf Southern Pine of dense select grade are in general specified for all important members and can be recommended without exception. There is but little choice between full and empty cell treatment processes with a 12-lb. specified retention for this climate, although the state's specifications call for the full cell treatment. Wherever cribs are used, it will be assumed that rock or broken concrete will be used to fill the crib and provide the required bearing and weighting of the crib and if capped with concrete that the crib shall be so designed as to insure that the timbers instead of the rock fill take the direct load from the concrete to insure against displacement cracks in the concrete.

When piles are driven in soft ground, a rock fill should be provided around the piles to stiffen them and tend to make a number of piles act as a single unit. Piles cut off below low water may in general be considered as permanent and need not be treated. Piles extending above water surface should always be treated unless for only temporary service, a known life of say five years or less. When piles extending above water surface are required to be treated, it must be remembered that the entire pile must be treated and only that part above water really needs it therefore, if any reasonable length is under water we must consider the alternative of cutting off untreated piles below water and capping with framed bents of treated material. In this latter case, we may use rectangular sticks and secure a much better looking job and one in which the bracing is much more effective because of vastly better connections.

Roadway.—In considering this study, we will keep in mind a design for a 20-ft. roadway inside of curbs as the minimum to be recommended. We will also keep in mind a provision for 18-in. safety walks as also a necessary minimum requirement. We will consider that for those cases where timber stringers are used the standard span is 19 ft. center to center of bents to correspond with the generally adopted practice and permit the use of standard 6x14 in. stringers, which are quite generally stocked and have adequate strength if properly spaced. For the longer spans requiring steel beams, a standard span of 40 ft. will be considered as the minimum which will safely pass ice and drift in major streams and be fairly safe from excessive scour and is suitable for multiple spans in large streams. The life of a structure is greatly dependent upon its appearance and it is a serious mistake to neglect this item in any attempt to reduce the cost of a structure. At the first signs of decay its looks are against it and the desire on the part of local people to preserve it does not exist. Perhaps no part of a structure more quickly affects the public opinion in this respect than a poor looking or inadequate railing or a poor wearing surface.

Railings.—Any satisfactory railing should provide that no openings shall be large enough to permit a child to crawl through them as bridges seem to offer peculiar inducements to children to play on them and we have record of many complaints and of two deaths from such inadequate provisions. Such a design requires that horizontal rails be spaced not greater than 9 in., and preferably 6 in. in the clear, and as a railing should have a height of not less than 3 ft. there should, therefore, be not less than three lines of rail for the ordinary timber or gas pipe rails. All railings should be able to resist a horizontal loading of 100 lb. per lineal foot applied at top of rail. This will generaly require for timber rails 6x6 posts at about 8 ft. centers adequately bolted to the deck to develop its full flexural strength, and a flat top cap of not less than a 2x6, a 2x8 being preferable and generally used in connection with 2x6 rails. For gas pipe rail, the post should generally be 3-in. pipe with specially designed anchorage to develop its flexural strength, this being a glaring defect of most gas pipe railings, and rails of not less than 2-in. pipe.

Bridge Curb.—Since the curb is so integrally related to the railing its details will be considered here. Curb should be designed to withstand a loading of 50 lb. per lineal foot in either a horizontal or vertical direction and should be neat looking and wear resistant, and if of timber, should preferably be of white oak. A curb should also have a height of about 10 in. to prevent wheels climbing it as the railing is in general inadequate to resist runaway motor trucks. A 6x6 white oak curb with bevelled corner would, therefore, have to be supported at about 8-ft. intervals to provide for the above loading, and it is good practice to make this 4 ft. When either timber or concrete curbs are used, it is desirable to provide 4-in. scupper openings under the curb for as large a proportion of the length of the bridge as possible, not only for drainage but to assist the wind in keeping the floor clean from debris and snow. Scupper blocks should therefore be short. An 18-in. clear walkway will permit pedestrians to keep out of traffic and this detail will considerably affect railing and curb design, and for modern high speed traffic, should always be provided.

The Floors.—For timber floors, this walkway will usually consist of transverse creosoted 2x4's laid flat and with ⅜-in. openings, supported by the curb on the inside and by a fascia rail on the outside. It is readily admitted by all that a timber or gas pipe railing is not handsome. A timber guard rail of the type noted will cost about $1 per lineal foot of rail and gas pipe rail about $1.25. A special ornamental structural steel railing is desirable when concrete curb and fascia are used and may be built up in a very satisfactory manner, using two 6-in. channels for posts and three 3-in. channels for sails and 1½ x5/16-in. bars for ornamental grill treatment and should cost around $1.50 per foot. A concrete spindle rail, such as is the state's standard practice, will cost about $5 per lineal foot of railing. The ornamental steel railing is recommended for the type of structure here considered with the provision of concrete or other terminal design at the approaches to properly set the railing off and provide a large white surface warning of the restriction of shoulder width at these structures.

Approaches.—When timber substructures are used, the approach terminals may each approximately consist of four timber guard posts of 8 in. diameter, arranged side by side, with round caps and painted white with black caps and bases. The law requires parking spaces or wide shoulders off of the traveled way and restriction at bridges is economically logical and is safe so long as the public sticks to the traveled way when in motion and a proper and plain warning of termination of parking shoulders exists. It is impractical and financially impossible to provide the extra parking width on the type of bridges here considered.

Curb and fascia treatment are very important from the standpoint of ap-

pearance and, if possible, concrete for such purposes is very desirable and not expensive even when timber stringers are used but should also be used only when either the ornamental steel rail, gas pipe or concrete rail are used. This should preferably be used only when a concrete floor is provided, although it is feasible for timber floors. Curb, safety walk and fascia treatment, including slab outside of face of curb, is roughly estimated to contain material quantities per lineal foot of bridge as follows: For concrete slab floors on timber stringers, 0.222 cu. yd. of reinforced concrete; for concrete slab on steel stringers, 0.146 cu. yd. of reinforced concrete; for concrete slab on timber cross ties on timber stringers, 0.252 cu. yd. of reinforced concrete; for timber walks and fascia, 30 F.B.M. of creosoted timber.

The Floor System.—For timber stringers either 6x12 stringers for a 15 ft. span or 6x14 for a 19 ft. span will require practically the same transverse spacing. The spacing transversely depends on load distribution through the floor, a wheel concentration distributing over a greater width with a stiff floor and, therefore, permitting a wider spacing in such cases. For legal loading only, these stringers may be spaced 18 in. centers for single 3 in. transverse plank floors, either with or without gravel asphalt or block surfaces, or may be spaced at 20 in. centers for concrete floors and transverse plank or ties with longitudinal plank surfacing adequately nailed. If it is desired to use steel stringers for the 19 ft. spans, these should be 12 in. by 6½ in. by 34 lb. Carnegie beams at the same spacing but can be used up to 4 ft. spacing and at the smaller spacings will cost 91 ct. per square foot as against 61 ct. per square foot of roadway for the creosoted timber stringers, but if used at wider spacing for which their strength is adequate, say even 36 in. instead of 18 will cost only 45 ct. instead of 61 ct. as for timber and, being durable, should always be used in preference to timber. If a 40 ft. span is considered and steel stringers used, these may be designed either for legal loading and temporary flooring or for specification H 15 loading and permanent flooring so as to be adequate for re-use when the bridge is rebuilt in the future.

For economy these beams may and should be designed for considerably greater spacing than the relatively short span timber beams or the steel beams of shorter span and a spacing of five feet, such as corresponds with the state's practice for its standard deck girder bridges, will be considered and the different types of flooring will then simply affect the weights of the beams. For such cases, it is found that 24 in. Carnegie beams will satisfy all four of the following cases requiring 85 lb. beams for legal loading and timber floors, 140 lb. for specification loading and ability to ultimately take a concrete floor with wearing surface but with only a timber floor at present, 130 lb. for the preceding case but with light concrete floor without wearing surface, and 110 lb. for state's standard design. These designs for stringers give for timber stringers 6.2 and 5.6 F.B.M. or 31.0 and 28.0 lb. of creosoted timber per square foot of net roadway and for steel stringers or beams 22, 37, 34, and 29 lb. of steel per square foot of net roadway respectively.

The Floor Material.—Considering now the floor material itself, we note that the simplest and most commonly used material is transverse plank which for legal loadings may be used alone without other distributing layers for stringer spacings not greater than about 16 in. for 3 in., 24 in. for 4 in., and 48 in. for 6 in. plank, based on full thickness plank. If 2 in. longitudinal plank is used on top of the transverse plank this spacing may be increased to about 24 in., 42 in., and 60 in., respectively. If transverse laminated plank are used and adequately spiked continuously to adjacent plank throughout the length of the bridge, stringer spacings of 30 in. and 60 in. may be used for commercial 4 in. and 6 in. timbers, i. e., 2x4's and 2x6's. If 2 in. longitudinal plank is laid on cross ties, 6x6 ties may be used up to 60 in. stringer spacing if spaced longitudinally 12 in. center to center, which is about as great as the 2 in. plank is good for.

For legal loadings, a concrete slab floor suitable for timber stringer spacing of 20 in. should have an overall average thickness of 4½ in., requiring 0.0159 cu. yd. of Grade A reinforced concrete per square foot of roadway and weighing about 65 lb. per square foot with provision for a 1 in. crown. Similarly for the steel beam design, such a slab will have an average gross thickness of 6½ in. and will contain about 0.0201 cu. yd. of Grade A reinforced concrete and weigh about 82 lb. per square foot of net roadway. If the state's standard slab and wearing surface is provided, the slab will have a gross depth of 6½ in. and wearing surface a depth varying from 3 in. to 4 in. and will contain 0.0201 cu. yd. per square foot of net roadway in the slab and 0.0114 cu. yd. per square foot in the wearing surface with a corresponding total weight of 128 lb. per square foot.

Wearing Surfaces.—Wearing surfaces on timber floors may, for plank adequately fastened down, be 2 in. longitudinal wood plank, wood block, Carey asphalt plank, asphalt block or brick or may be concrete and will contain 2 ft. board measure per square foot, weighing 10 lb. per square foot, four and one-fourth wood blocks per square foot weighing 15 lb. per square foot, 1 sq. ft. of 2 in. Carey plank weighing 19 lb. per square foot, four and one-fourth asphalt block or brick weighing approximately 21 lb. per square foot, or 0.0132 cu. yd. (4½ in. average) Grade A concrete per square foot and weighing 53 lb. per square foot respectively. Evidently the timber floors themselves will contain for 3 in. plank or laminated floor three F.B.M. weighing 15 lb. per square foot, for 4 in. plank or laminated floor four F.B.M. weighing 20 lb. per square foot, and for 6 in. plank six F.B.M. weighing 30 lb. per square foot, and for 6x6 ties at 12 in. center to center only the same quantities and weights as for 3 in. plank, indicating the economy of this construction. Timber bridging at the third points should be provided for each pair of timber stringers and concrete diaphragms not less than 6 in. in thickness provided at the quarter points for each pair of steel stringers.

Design of Substructure.—We are now ready to consider the substructure design. The combined dead and live and impact loads for legal loading with timber floors and for specification loading with concrete floors and wearing surfaces will be approximately 85,000 and 187,000 lb. for piers concentrations and 69,000 and 138,000 lb. for abutment concentrations respectively for the 19 ft. spans with timber stringers and for the 40 ft. spans with steel beams, 126,000 and 301,000 for piers and 84,000 and 178,000 for abutments respectively. These loadings in themselves will require 4, 10, 4 and 7 piles for the 19 ft. spans and 6, 16, 4 and 9 piles respectively for the 40 ft. spans, assuming that all piling will be of 10-ton capacity and disregarding the substructure weights and other outside forces. It is not safe for general design of piling to assume any greater capacity than 10 tons and it is often impossible to secure more than about 6 or 7 tons.

Piling extending above the water surface should be adequately braced, bracing fastened at each intersection by at least one ¾ in. bolt and additional boat spikes, or log screws of adequate length and bracing, should be arranged on each side of the piles to be effective and if water is of appreciable depth, bracing should extend about 3 ft. below water surface, particularly in soft soils. This may be readily accomplished by bolting on the brace just at water surface when it is estimated from driving other piles that about 3 ft. additional driving will give the required bearing capacity. The above figures readily indicate the inadequacy of the customary 4-pile bent for many of the structures so frequently encountered. They also indicate the necessity for double bents for piers for 40 ft. spans with concrete decks, as it is impractical to drive piles at closer intervals than about 2 ft. 6 in. and a 20 ft. roadway does not permit a cap length which will take over 10 piles at this close spacing. . The size of caps and sills is well standardized at 10 x 12's and for 10-ton pile loadings a cap or sill of this size may be considered as able to distribute a 10-ton central loading over a spacing of piles

or posts of about 6 ft. A 10 x 12 post in the customary heights is well able to take the loads for this spacing and, therefore, for close pile spacing it is economical in such cases to cut off piles below low water and use creosoted framed bents of 4 posts each above water.

It is easy to show also that there is but small and negligible increased cost for such construction even when pile spacing is greater, and for standard construction, this design is recommended. A vast improvement in appearance is thus guaranteed and more rigid bracing assured. For such framed bents, it is desirable that at all joints a ½ in. steel plate be adequately bolted on each side to all intersecting members. Such construction will require, however, that the flexural strength of the piles for load components at right angles to the bents be made up by bracing the adjacent bents in pairs and this must be done adequately and in a manner that will not catch ice and drift. For low bents, this bracing may often be dispensed with but bolted scab splices of steel plates are desirable in such cases, lapping over piles, and bottom of posts a sufficient distance to permit developing a fair proportion of the pile strength in flexure.

Double Bents.—For double bents, the bents must be spaced about 2 ft. 6 in. to permit driving of piling and the adjacent bents must be rigidly bolted and braced to each other. For comparison and to give a general idea of costs in a later summation, it will be assumed that our typical bridge has a height from bed of stream to necessary underclearance of 8 ft. 6 in. with a stream depth of 2 ft. 6 in. at low water, 3 ft. 6 in. at normal water, and pile cutoff 1 ft. 6 in. below low water and an average pile penetration of 15 ft. For such conditions, we will have for single bent piers of 4 and 10 piles respectively 910 ft. board measure of creosoted lumber and 76 lin. ft. of piling or 910 ft. B. M. of creosoted lumber and 190 lin. ft. of piling likewise for double bents of a total of 10 and 16 piles respectively, we will have 2,000 ft. B. M. and 190 lin. ft. and 2,000 B. M. and 304 lin. ft. respectively. The above figures may also be used substantially for abutments of 4 and 10-pile single bents provided the piles do not also serve to support plank or other retaining wall units.

Timber Cribs.—When hard bottom is encountered and piling absolutely can not be driven, it being always kept in mind that piling is superior from the standpoint of safety from scour, it becomes necessary to excavate in open water a depth of say about 3 ft. below bed of stream and sink an untreated timber crib to proper bearing and proceed to fill the same with rock or broken masonry and to likewise fill the entire excavated space outside of and around the crib with a liberal filling of similar material. For ordinary structures, cribs made of 6 in x 8 in 8 ft.—0 in. ties in good condition will prove adequate and economical, care being taken to seat the cribs firmly on hard bottom and to level the bottom off carefully before placing.

Every intersection of cribbing material should be firmly fastened by ¾ in. headless dowels of a length sufficient to pass through two sticks, lacking only 1 in., and to provide that the two bottom layers shall be closely spaced, say 6 in. clear, to adequately support the rock fill, a small part of which must also be counted on to provide the weight for sinking the crib. 8 x 8 cribs should be placed closely alongside to build up a pier of adequate length. Such piers provide a bearing area on timber surfaces of 576 sq. in. per 8 x 8 crib, which is amply adequate for any loading that may be anticipated.

Each such crib also provides a bearing area on the soil of 112 sq. ft. which, at two tons per square foot, is easily able to sustain a total load of 224 tons which will permit the use of a concrete pier on top of the crib, the crib itself being adequate for this load independent of the support of the rock fill which would be questionable in itself due to its tendency to shift position of particles under the action of the stream and ice. Timber cribs of this type will contain 1,344 F. B. M. in the two bottom courses of aggregate height of 1 ft. and 576 ft. B. M. per each additional foot of crib height, with a corresponding crib rock fill of 5.5 cubic yards per foot of height above the two bottom courses. For the assumed conditions, the top of crib will be 6 in. below low water and will contain for one pier of abutment 3,648 ft. B. M. untreated timber and 22 cu. yd. of rock fill, to which should be added the fill around the crib of about 54 cu. yd. or a total of 76 cu. yd. of rock fill.

Abutments.—In the design of abutments, it is common practice to use 4 in. horizontal plank back of the piling and this is adequate for practically any ordinary case which may be encountered, provided the pile spacing does not exceed about 6 ft. Such back walls should extend below probable scour line and we will assume they extend to 1 ft. below low water and that the bank slope cuts the back wall at an elevation 2 ft. above normal water and that the bank consists of firm material. At a 6 ft. pile spacing, this back wall will require 1,800 ft. B. M. creosoted lumber and 4 additional piles of 23.5 ft. average length or 94 lin. ft. of creosoted piling per abutment. The piles, in addition to taking vertical loading, are subject to a very severe flexure. At 6 ft. spacing of piles, this load alone would tax the design limit of such piling for underclearance heights above low water of only 7 ft.

It is apparent that for most abutments of this type piling is seriously overloaded and in face of this pile spacing should be limited to 2 ft. 6 in. for piles taking combined superstructure and back wall loading and to 5 ft. outside, and that this type should not be used for heights above the figure noted. The proper solution in such cases is an earth filled tie crib design similar to the under-water cribs previously described with the omission of the two bottom courses and constructed inpendently behind the pile bent, it being estimated that this crib relieves the piles, requires but little more excavation in general, and contains but little more backfill with no borrow and presents a much better appearance if well built and contains 4,850 ft. B. M. of creosoted timber per abutment.

Concrete Piers.—In case a concrete pier is required or desired, the footing should extend 6 inches lower than the top of crib or pile caps as the case may be and will be formed on a rock fill around the piles after topping the rock fill with gravel. The bottom of footings will thus be 2 ft. below low water. Footings 6 ft. by 1 ft. 9 in. gross depth should be the minimum section used and are adequate for the heaviest loading here considered. Such footing will in general be tremied in place without pumping but using a rich concrete or a form may be used and a seal course placed in addition to the footing and the form pumped and concreted in the dry.

The pier shaft may be a 12 in. reinforced wall 5 ft. 3 in. high to bridge seat terminated and intermediately braced with four 2 ft. 6 in. by 1 ft. 3 in. pilasters on each face, to provide not only stiffness but also an adequate resistance to ice and drift. The bridge seat should be 2 ft. 8 in. by 1 ft. 3 in. section to furnish proper bearing and adequate aesthetic treatment. Such a pier design is recommended for use with tie cribs of design previosuly described and also for use on pile foundations. Such a pier for the conditions herein considered will contain about 16 cu. yd. of concrete and 3,400 lb. of reinforcing steel, including bridge seats, which contain two I-beams for seating the longitudinal steel girders or timber stringers. For such piers on pile foundations, there should be provided 20 piles per pier or a total of 440 lin. ft. of untreated piles and 600 ft. B. M. creosoted caps. There will also be required in general about 40 cu. yd. of rock fill per pier if piles are used.

Concrete Abutments.—For concrete abutments on pile foundations for these assumed conditions, a semi-gravity type is economical and a footing similar to the previously described pier design is desirable. Such a footing should have a minimum section about 8 ft. by 1 ft. 9 in. gross depth. The body will be about 38 ft. long to permit straight wings and straight sloping concrete back walls. The body wall should have a minimum thickness at top of 1 ft. and at top of footing of 6 ft. 6 in. with reentrant back batter. The back walls

will be considered as 1 ft. thick and monolithic with the floor slab, the stringers being extended flush with the back of the abutments and the back wall lapping over behind the abutment wall to a depth about 6 in. and clearing the same by 1 in. to permit of expansion, the gap at the bottom of back wall being waterproofed with triple folded asphaltic membrane. The back wall wings should be reinforced properly for the cantilever projecting a length of about 7 ft.

The abutment wings will be returned in U shape to be terminated by a vertical plane flush with the rear of the abutment footing. This design will require about 37 piles for each abutment. Such a design will contain about 47 cu. yd. of concrete, 3,500 lb. of reinforcing steel, and 700 lin. ft. of untreated piles and 950 ft. B. M. of creosoted caps. It should not necessarily require any rock filling. If designed to a seat on a rock filled crib, the same general details of crib design used for the pier will suffice and such an abutment design requires but little modification from that already described but the crib will require about 5,750 ft. B. M. untreated timber and 120 cu. yd. of rock fill.

Cost Comparison.—We are now in position to sum up the results of our study and then decide as to just how desirable from the standpoint of the capitalized saving ratio, as well as from the factor of initial investment reduction, the various types proposed really are. Our comparison will be based on three bridges of about 40 ft. total span of cheap timber grade, cheapest permanent type and State's standard type as hereinafter more completely described, then three more bridges of about 80 ft. overall span of similar make-up. For a bridge of 39 ft. length, consisting of two timber spans of 19 ft. each, we find that the following quantities are required:

For 3 in. transverse plank floor on timber stringers, legal loading, plank walkways, timber railing, on creosoted framed abutment and pier bents on under water untreated piling with creosoted plank backwalls, we need 14.71 M. B. M. creosoted timber, 0.51 M. B. M. untreated timber, 416 lin. ft. untreated piling which, together with rock fill pier protection and excavation, are estimated to cost about $2,377 or an average of $3.05 per square foot of net roadway surface secured, these figures being exclusive of engineeriing and supervision. This is the cheapest design for the conditions assumed which would be considered as desirable. This will be hereafter referred to as Bridge A.

For a single span of 42 ft. length with concrete slab floor on steel stringers, H 15 or specification loading, without weariing surface, concrete curb, walkway and fascia, ornamental steel railing, concrete abutments on untreated timber piles, together with rock protection at pier and excavation, we need 32.7 cu. yd. of Grade B concrete, 94.0 cu. yd. of Grade C concrete, 28,600 lb. of structural steeel, 4,650 lb. of reinforcing steel, 84 lineal ft. of metal railing, and 1,400 lin. ft. of untreated piling, which is estimated to cost about $6,919 or an average of $8.25 per square foot of net roadway surface secured. This is the cheapest design for the conditions assumed which will give a permanent type of structure. It has its limiting conditions for use as compared to the state's standard designs and is otherwise less desirable but it can properly be classed as permanent construction. This will hereinafter be referred to as Bridge B.

For the same conditions, the state's standard designs for a 40 ft. span with 22 ft. roadway with 18 in. safety walks and concrete wearing surface on semi-gravity concrete abtuments with footings extended to 3 ft. below stream bed, no tremie concrete, and on untreated timber piles, it is estimated that we will require 57.0 cu. yd. of Grade B concrete, 175.0 cu. yd. of Grade C concrete, 23,000 lb. of structural steel, 9,900 lb. of reinforcing steel, and 766 lin. ft. of untreated piling, and it is estimated that such a structure would cost about $9,160 or $10.30 per square foot of net resulting roadway. This will be referred to as Bridge C.

We will now consider similar bridges as follows: Bridge AA same as Bridge A but with 4 spans of 19 ft. or a total length of 77 ft.; Bridge BB same as Bridge B but with 2 spans of 40 ft. or a total length of 82 ft.; and Bridge CC same as Bridge C but with 2 spans of 40 ft. each or a total length of 80 ft. Bridge AA will contain 24.7 M. B. M. creosoted timber, 1.01 M. B. M. untreated timber, 380 lin. ft. untreated piling, and is estimated to cost about $3,681 or an average of $2.38 per square foot of net roadway secured. Bridge BB will contain 63.6 cu. yd. of Grade B. concrete, 110 cu. yd. of Grade C concrete, 56,000 lb. of structural steel, 18,100 lb. reinforcing steel, 164 lin. ft. of metal railing, 1,780 lin. ft. of untreated piling, and 76 cu. yd. or rock protection, and is estimated to cost about $10,897 or $6.66 per square foot of net resulting roadway. Bridge CC will require 114 cu. yd. of Grade B concrete, 240.5 cu. yd. of Grade C concrete, 46,000 lb. of structural steel, 17,380 lb. of reinforcing steel, and 1,246 lin. ft. of untreated piling, and is estimated to cost about $14,831 or $8.40 per square foot of net resulting roadway.

Assuming Bridges C and CC as standards, the saving ratio S divided by Co will be 70.5 per cent, 20 per cent 72 per cent, and 20.6 per cent for Bridges A, B, AA, and BB respectively and these cheaper types may thus be economically scrapped after periods of exist of 7½, 33 6½, and 32 years respectively. Similarly, if Bridges B and BB be considered as the standard, being permanent types, the saving ratio for Bridges A and AA would be 63 per cent and 64 per cent respectively and would warrant scrapping after 6½ years in each case.

If hard bottom requires the use of cribs instead of piling for Bridges B and BB, the costs of these jobs will be increased by $815 and $1,130 or by 11.6 per cent and 10.4 per cent respectively. If a crib backwall is used instead of the plank backwall, Bridges A and AA will be increased in cost by $508, an increase of 21.4 per cent and 13.8 per cent respectively.

The use of untreated longitudinal plank wearing surfaces on creosoted transverse plank is not warranted except in maintaining existing bridges since 2 in. plank on 6 x 6 cross ties is just as cheap and much stronger and more rigid. This type of floor will increase the cost of Bridges A and AA by about $156 and $308 respectively or only 6.6 per cent and 8.4 per cent respectively and this additional expense is well warranted in consideration of the reduction secured in the average annual maintenance charge.

Two inch Carey plank instead of 2 in. timber plank will likewise increase the cost of Bridges A and AA by $700 and $1,380 or by 29.5 per cent and 37.5 per cent respectively. The saving, by using 2 inch longitudinal plank instead of Carey plank, is $544 and $1,072 respectively or there is a saving ratio of 77.5 per cent in either case, which indicates that the plank floor must last about 5½ years to justify the use of the timber plank, provided, however, that the Carey asphalt plank must give satisfactory service for a period of at least 17 years. However, inasmuch as 3 or 4 years is considered good service for 2 in. plank and the probable life of the Carey plank around 10 it would appear that, with good timber plank, aside from the nuisance to the public from renewals, that the case was about even for either type at present prices of Carey plank, a 3 or 4 year life of 2 in. plank requiring 11 to 14 years life of Carey plank for equal annual charges.

The longitudinal plank is the lightest and cheapest of all wearing surfaces and is very rigid. However, a concrete wearing surface either on timber stringers for the 19 ft. spans or on 6 x 6 cross ties for either the 19 or 40 ft. spans with steel stringers costs but very little more than the longitudinal plank and is, of course, much heavier but for new design, it should always be used instead of any other surfacing since its annual charge is negligible in addition to practically no increased cost.

From the studies just made, it will be found that the cost of superstructure for Bridges AA, BB, and CC respectively is $2,290, $5,170, and $6,588, or $1.47, $3.15, and $3.72 per square foot of net roadway, or the ratio of cost of superstructure complete to the entire cost of structure is 62.2 per cent, 47.5 per cent and 44.3 per cent respectively. In many cases, the cost of abut-

ments can be almost eliminated by the addition of a short length of superstructure and thus securing the advantages of high banks. If one span of superstructure is added, this also adds a pier but saves a large portion of the abutment cost or, in general, the extra span should be added if S is equal to or less than P-(B1 — Bo) where S is the cost of one span of superstructure, P the cost of one pier, B1 the cost of one original abutment, and Bo the cost of the new or shallower abutments.

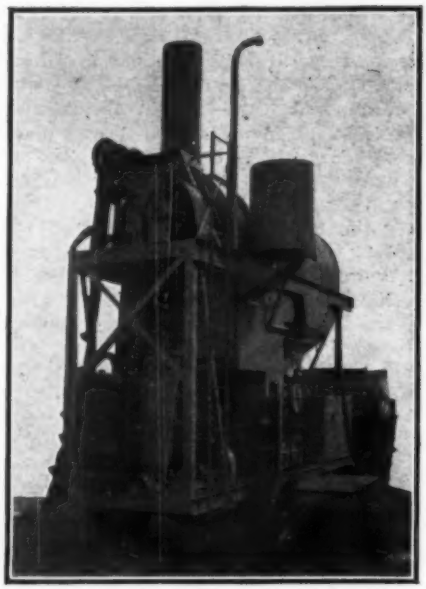
In the preceding studies, the saving ratio for Bridges B and BB are not large enough to make the saving attractive in view of the fact that while these structures are of the permanent type they are somewhat inferior in appearance and have not the protection from scour afforded by Bridges C and CC. However, in deeper water and in the soft foundations, the saving ratio for this type will be much greater and will approach 50 per cent corresponding to a life period of only 14 years and unquestionably such a saving justifies the construction of this type on even our trunk line highways. The saving ratio for this type should always be carefully investigated before proceeding to design a CC type of bridge.

In conclusion, we may in general, subject to the limitations of this study, say that when the limitation of money available or other reasons make it inadvisable or impractical to adopt the state's standard bridge practice for permanent structures, it is not ordinarily desirable to adopt any intermediate designs for a cheaper structure but rather that we should go to the Type A bridge or a modification of this type using steel stringers instead of timber and provided further that a concrete floor on the 20 ft. roadway strip should be used instead of the plank assumed in this study for the Class A bridges. The work should be carefully and neatly done, painted and creosoted parts neatly finished and approaches as well considered and cared for as for a permanent structure. It is very apparent that such timber structures are easily susceptible to standardization and it is the hope of the State Highway Department that it will be able to prepare and make available, for the free usage of public highway authorities, standard plans and specifications along the lines outlined in this paper, during the 1928 season.

Acknowledgment.—The foregoing is a paper presented at the 14th Annual Michigan Conference on Highway Engineering, held at the University of Michigan, Feb. 14 to 17, 1928.

A 500 Lb. Portable Plant for Maintenance

The Madsen Junior is a complete, self-containing asphalt paving plant that includes modern features that lead to accurate and careful proportioning and mixing at a low cost. It has been designed for the low cost patching, resurfacing, and general maintenance of asphalt roadways and for the paving of alleys and crossings, for the adding of shoulders, and for other limited surface jobs.



The Madsen Junior Asphalt Paving Plant

This plant has been designed to deliver 60 to 75 tons per 8-hour day of regular specification mix, in 500-lb. batches on one-minute mix schedule, and should be able to cover surfaces in appreciable yardages without waste of labor or materials. Although its rated capacity is as stated above, the manufacturers claim an actual capacity of 15 tons per hour. The total net weight is 20,280 lb., and is built low enough to pass under trolley wires and narrow enough to require no special permit to move over street or highway. It requires a crew of one platform man and two shovelers. It is spring mounted on 36 in. by 7 in. front and 36 in. by 7 in. dual rubber tired rear wheels, and possesses a special steering linkage which insures precise tracking behind a truck or tractor when towed to location.

The production machinery comprises a bucket and belt elevator with receiving boot and headshaft hopper and chute, a 32 in. diameter by 10 ft. rotary dryer, a tapered three-sized rotary screen, and four-compartment stone and sand bin with quadruple bin gate, a 500-lb. capacity steel weigh box, mounted on 3 to 1 hardened steel knife-edged weigh beams and registering on a Chatillon dial scale, and a 500-lb. capacity two-spindle pug mill mixer with hard white iron renewable bottom and paddles.

The asphalt handling equipment consists of a 350-gal. steam heated tank with a special melting turret for handling barreled asphalt, a cylindrical asphalt weigh bucket hung upon 1 to 1 knife-edged weigh beam registering upon a Chatillon dial scale, the weighed asphalt flowing to the mixer through a distributing fan chute. A davit and power winch lift the barreled asphalt up to the melting turret.

Low pressure steam, superheated to any desired degree, is supplied to the asphalt heating coils from an Allen steam generating unit. Steam from the same source operates the dryer oil burner, which is designed to operate at low pressure. This generating unit consists of a generator and a No. 4½ B Root Rotary Blower of 100 cu. ft. per minute capacity at 5 lb. pressure, the blower being gear driven from the Hercules engine stub shaft. The Allen Generator, taking air at 5 lb. pressure from the blower, burns oil fuel and generates steam at about 4½ lb. pressure with any desired degree of superheat. Its operation, once started, is practically automatic and quite easy.

The entire plant is powered with a 30 h.p. Model O Hercules gasoline power unit, equipped with fuel tank and radiator in an enclosed housing, with a 4 to 1 reduction gear and clutch. It is manufactured by the Madsen Iron Works, Huntington Park, California.

New Mexico to Extend Highway Culverts

The State Highway Department of New Mexico has issued instructions to all the district engineers throughout the stae to immediately begin lengthening out all culverts which are too short and form a menace to traffic. The headwalls on many of these culverts at the present time project within the shoulder lines of the road, and as a result autos frequently run into them causing serious accidents. These headwalls are to be removed and the existing culverts extended from 4 to 6 ft. on each end. This order is universal throughout the state and the work of correcting this fault is to begin immediately.

In the past some attempt has been made to warn autoists concerning this undesirable condition by setting up posts painted white. These have not been altogether satisfactory, although a certain amount of good has been done.

According to the April New Mexico Highway Journal the work contemplated under this order will not only relieve the dangerous condition which exists at many places on many of our main highways but it will facilitate maintenance. Many of the headwalls form obstructions to maintenance equipment because of the fact that these headwalls are within the shoulder lines of the road and consequently offer interference to ordinary maintenance methods which contemplate the covering of the roadway from shoulder line to shoulder line.

History of Highways

An Outline Given in Paper at 1928 Michigan Conference on Highway Engineering at University of Michigan

By JOHN S. WORLEY
Professor of Transportation, University of Michigan.

In writing a history of highways—confining ourselves to highways for wheeled vehicles—we can be very sure that the earliest records we have—compared with the time when artificial highways were first used, may be quite modern.

We can best learn about our earlier highways by studying the vehicles which used them, for we have records of these early wheeled vehicles although the highways over which they traveled are entirely eradicated. The perfection in which we find these first vehicles is such that we know they can only be the resultant of many centuries of evolution.

The Stone Age Vehicle.—Our first written record of vehicles is found in the Swedish rock sculpturing in Southern Sweden, consisting of four-wheeled vehicles drawn by two horses. "It cannot be doubted that these pictures belong to a pure stone age, but we do not know how long ago this stone age was. It may well be as much as 10,000 to 20,000 years before our young era."

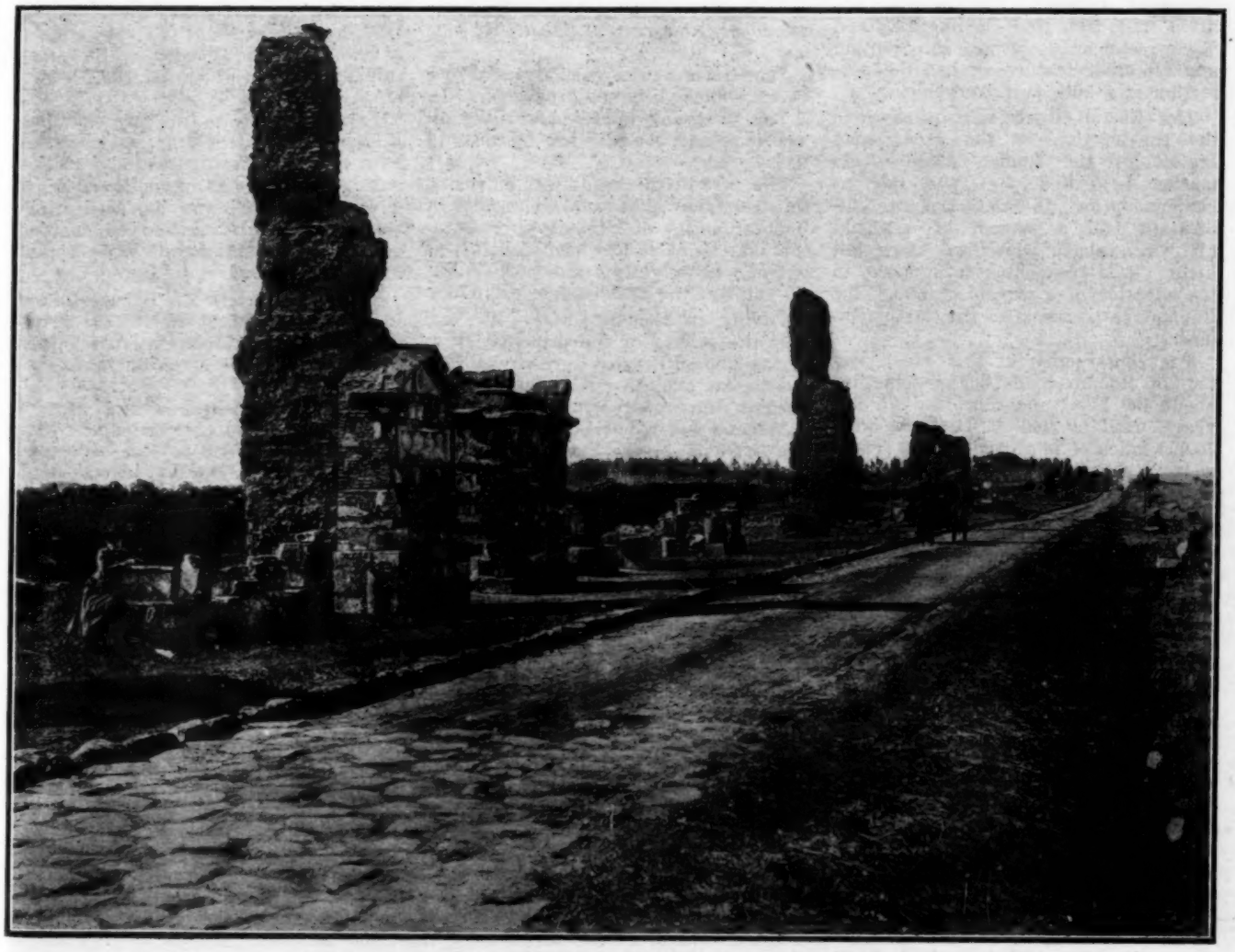
These sculpturings are crude as are all rock drawings, however, the advancement of the art of wagon building is shown by the wheels having spokes.

The Causeway for the Pyramids.—The stones for the first Egyptian pyramid constructed during the IV dynasty (2800 B. C. Breasted,—5000 B. C. Petrie) were brought from the Arabian mountains to the Nile; thence by water to within a short distance of the site of the pyramid. From here the large blocks of stone were transported over a causeway for the construction of which "Ten years were consumed in hard labor of forming the road through which these stones were to be drawn; a work, in my estimation, of no less fatigue and difficulty than the pyramid itself. This causeway was five stedia (3,000 ft.) in length, forty cubits (20 ft.) wide, and its extreme height thirty-two cubits (16 ft.), the whole is of polished marble, adorned with figures of animals."

Pococke who traveled in Egypt the first half of the 18th Century found "at this time there is a causeway from that part, extending about 1,000 yards in length, and 20 ft. wide, built of hewn stone. The length of it agreeing so well with the account of Herodotus, is a strong confirmation that this causeway has been kept up ever since, though some of the materials of it may have been changed, all being now built with free-stone. It is strengthened on each side with semicircular buttresses, about 14 ft. in diameter, and 30 ft. apart; there are sixty-one of these buttresses, beginning from the north. Sixty feet farther it turns to the west for a little way, then there is a bridge of twelve arches, 20 ft. wide, built on piers that are 10 ft. wide. Above one hundred yards farther there is such another bridge, beyond which the causeway continues about one hundred yards to the south."

Norden, another English traveler, about the same period as Pococke also mentions the two bridges.

Our next record is found in the Bible 1740 B. C., when Pharaoh commands



A Modern View of the Appian Way. The Most Famous Road in History.

that wagons shall be sent to bring the families of the brothers of Joseph to Egypt.

We find on the wall of the temples of Ninevah and Karnak sculpturing showing most perfect chariots and horses. Vehicles with the horses and accountrements having such perfection in detail is prima facia evidence of improved highways.

The Cnossos Road.—The oldest artificial road extant is one in Cnossos, Crete. "The Palace of Cnossos was approached from the west by a paved Minoan Way communicating with a considerable building on the opposite hill."[3] This road was constructed prior to 1500 B. C. Today it is intact, having a surface of paving stones which is sufficiently smooth for the satisfactory operation of a modern motor car. It has much of the appearance of a modern road. The roadway is about 10 ft. in width. Unfortunately, as far as I have been able to ascertain, no cross section of the roadbed has been taken or a study made of the construction details.

In the Metropolitan Art Museum of New York City is an Etruscan chariot, of about 750 B. C. Its body, wheels and pole were encased in beautifully embossed bronze. The wheels are fitted with iron tires ½ in. thick and ¾ in. wide. In design, construction and all other features it has the perfection of a 20th Century vehicle.

The Roman Roads.—In passing to the construction of the great road system of the Roman Empire, attention is called that the Carthagenians prior to the Roman civilization had a system of artificial highways, about which we know but little. It is reasonable to suppose, in the adoption of a system of roads, the Romans patterned after the Carthagenians.

The construction of this great system of Roman roads began sometime about 400 B. C. and continued for 600 years, until by 200 A. D. there were 70,000 miles of improved roads. There were 29 great military highways which radiated from Rome in every direction, comprising a total of 48,500 miles.[4] Every province of the Roman Empire was connected with the capitol by one of these main roads, and in addition there were many secondary roads for local use. While these roads were termed military roads their principal use was that of commerce.

Details of Roman Road.—The physical features of the Roman road will be of great interest to us. These highways were laid out in as direct routes as the topography of the country would permit.[5] "In the low and level grounds the roads were elevated to a considerable height above the adjoining lands and afforded an extensive view of the surrounding country."[6] The Roman construction was not uniform, though always extremely massive. The roadway ranged in width from 16 to 30 ft. with a depth of 3 to 4 ft., and laid in 3 or 4 courses. The top soil was removed, 2 or 3 ft. in depth, until a firm foundation was reached; and in case of soft ground all the soft material was removed and replaced by firm material or piling and grillage of brush, timber and such was used so as to obtain a firm foundation. The Romans seemed to understand how to avoid having poor pavement due to bad subsoils.

The first or bottom section, the statumen, was composed of two courses of flat stones laid dry or in lime mortar. The depth averaged 16 to 18 in.

The second course, the rubus, was composed of broken stone mixed with lime in the proportion of one part of lime to three parts of stone. This course ranged from 6 to 9 in. deep.

Section three, the nucleus, was composed of coarse gravel and lime used hot, or bricks or broken tile mixed with lime and covered with a thin layer of lime mortar.

The top or surface of the road, the summa crusta, or pavementum was constructed of smooth surface polygonal blocks of granite or hard lava joined with a nicety that scarcely any seam or crack could be seen. This course was 6 in. thick.

Each edge of the paved surface was provided with a curb of stone 2 ft. wide and 18 in. high.

Sometimes a narrow side road 6 to 8 ft. wide flanked the main pavement.[7]

The foregoing approximates the dimensions and construction features of the Appian Way.

The care of the roads was entrusted to a person of high rank. The office of Superintendent of Highways, or Curator Viarum as it has been called, was one of great dignity and honor. Julius Caesar was the first to hold this office.

Paving in Roman Cities.—We find that the streets of the principal cities of the Roman Empire were paved. Archeologists exploring the ruins of these ancient cities report not only of finding pavement and sidewalks but signs of dense travel in the ruts worn in the pavement by the wheels of the wagons and chariots which passed over them. Camillius in 396 B. C. gave ladies the right to drive their carriages through the streets which privilege was withdrawn in 190 B. C. Lycurgus, 800 B. C., in reforming Athens forbade the use of carriages by women. His own wife violated the law, and was arrested and fined 6000 drachms ($600.00). So we see that traffic regulation is not a problem new to municipal officers.

The road program of the Romans reached its zenith by 200 B. C. Paved roads had been constructed in every important province. By this time they had built extensive road systems in England, France, Spain, Egypt, Germany, Arabia, Asia Minor and Northern Africa. With the beginning of the decline of the Roman Empire road building ceased, which was followed by the roads going unrepaired.

The First English Law for Roads.—During the Dark and Middle Ages no roads were built and the only travel was by foot or upon the back of animals. It was in 1285 A. D. tht Parliament passed the first act regarding highways in England which act required all trees and brush to be cleaned on each side of the Kings highways for a distance of 200 ft. This was to prevent concealment of robbers.[8]

In 1555 Parliament passed an act providing for surveyors to have charge of the roads, however, these were all earth roads which much of the time in the winter were next to impassable.

In 1556 France built a stone road, 15 ft. in width, between Paris and Orleans, a distance of approximately 100 miles. This can be said to be the Renaissance of improved road building. However, it was not until the very last of the 18th century when John Loudon McAdam returned from America to Scotland coupled with the work of Telford that road building began in earnest. The improved facilities for transportation, at the beginning of the 19th Century, in England and all Europe, furnished the means for rapid commercial growth of all these countries. These highway transportation facilities were being further augmented at the time, 1800, by large systems of inland canals, and were further added to by the great railway systems which had their beginning in 1830.

From 1830 on to the present time England and all European countries have had their transportation facilities enlarged each year by additional mileage of railroads and surfaced highways. The cultural and commercial growth during this period exceeds that of all prior time.

The Development of Transportation in the U. S.—The history of the development of our transportation facilities in America can be given in the following order:

1. Unimproved highways;
2. Canals, 1800 to 1840;
3. Railways, 1830 to date;
4. Improved highways, 1910 to date.

It is true we had a few improved highways prior to 1910 but the decade 1910 to 1920 is when we began in earnest to construct improved roads. And it is within the last two decades in which we have had the greatest development.

You will readily recognize I have given you the merest outline of the history of highways. It obviously represents or is an epitomization of a more detailed history covering a period of approximately 7,000 years. As one pursues this history as found in many sources the outstanding thing is the fact that the growth and heights attained by all civilization have been dependent upon the means of communications. In Egypt a country where its population occupied a strip of land 2,000 miles long by an average width of approximately 30 miles, the river

Nile was its principal highway. Persia, Carthage, and Greece had the Mediterranean Sea which was supplemented by local artificial highways.

Rome through having the Mediterranean Sea as a means of transport, feeling that artificial highways were of the greatest importance, planned, constructed and kept in repair a system of roads which achievement may not have been surpassed by any other nation of the world, our own possibly not excepted.

The civilization, culture and commercial importance of England and all other European countries advanced as the artificial highways, canals and railroads were constructed.

Conditions in South America.—If we enquire into the conditions of the countries of South America we find those most advanced have the most complete systems of communication while those the least advanced have little or none. Argentine with its 22,587 miles of railways stands in first place, while Colombia with 740 miles, Venezuela with 535 miles and Equador with a mere 365 miles of railway are last. In natural resources all of these later countries probably equal or surpass Argentine when compared on the basis of area —that is wealth per square mile.

In the United States our first great period of advancement, our period of railway development, was 1830 to 1910. In 1830 we had 73 miles of railways which in 1910 had reached a total of 239,991 miles.

Our next great period of advancement in the United States is that period which began in 1900 and which probably will not reach its ultimate acceleration for several more decades—the good roads period. In 1904 we expended upon our roads approximately $79,000,000. By 1926, out of a total mileage of 3,001,825 miles of highways the total paved amounted to 521,915 miles or a little more than one-sixth of the total mileage. In 1926 we constructed approximately 35,000 miles of new pavement and our total road expenditures amounted to approximately $1,000,000,000.

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[4]Healy, Edmund. A Practical Treatise on Roads. 1844.
[5]Blanchard, Arthur H. Elements of Highway Engineering. 1915. p. 4.
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[8]New International Encyclopedia. Vol. 20, p. 28.

Missouri Gets $6,500,000 from Gas Tax.—The 2-cent state gasoline tax in Missouri yielded a total of $6,444,385 in 1927 for the state road fund. The gasoline tax collections increased 15 per cent in 1926 over 1925 and 28 per cent last year over the year preceding.

Maintenance of Way Charges Against Public Carrier Busses

Some pertinent facts with reference to present methods of bus taxation and the application of the tax funds to road construction and maintenance are given in Bulletin 85, issued a few days ago by the Engineering Experiment Station, Iowa State College, Ames, Ia. The bulletin was written by W. W. Hitchcock, assistant professor of civil engineering, Michigan State College of Agriculture and Mechanic Arts. The bulletin presents data on the rates of taxation applied to common carrier busses in Michigan and Iowa and on the aggregate sums obtained from motor vehicle taxation in those states. There are also presented certain data having a bearing upon the equitableness of the bus tax systems in the two states, particularly in comparison with the taxes imposed on the automobile. An analysis of the sums that will be required for highway purposes is included to indicate whether the present rates of taxation on motor vehicles are likely to provide sufficient funds for the highway programs of the two states. The general conclusions given in the bulletin are as follows:

The development of the motor vehicle has brought about extensive highway improvements. These improvements have called for large sums of money which have been obtained in various ways, but at present the prevailing opinion is that the motor vehicle owner should pay the cost of maintaining the principal motor highways. A study has been made of the income from the registration of motor vehicles in the states of Michigan and Iowa to determine whether or not this income is sufficient to maintain their primary highway systems.

The common carrier motor bus is in its infancy. Operators of bus transportation lines are inexperienced in the management of this new enterprise and state governments are feeling their way slowly in adopting regulatory legislation. Pennsylvania, in 1924, segregated motor vehicles used as common carriers and placed them under the State Public Service Commission. Today the laws of forty state provide comparatively complete regulation of common carrier busses. There are as many regulatory systems as there are states putting them into operation.

The question of equitably taxation is one of the most important to be considered in the passing of laws regulating the common carrier motor bus. Each state has its own problems and it is not to be expected nor desired that the rate of taxation should be the same in all states. The rate of taxation, however, should be in keeping with the tax assessed against other vehicles that use the highways.

The assessment of taxes against motor vehicles in proportion to the use or, and benefits received from the highways over which they operate, is a long step away from the more common idea of taxation in proportion to ability to pay. Since this benefit method seems to meet with rather general approval, a definite means of distributing the taxation should be determined so that the various classes of motor vehicles will be taxed in proportion to the benefits accruing from the development of highways.

A careful study has been made of a large number of public carrier busses operating over the highways of the states of Michigan and Iowa for the purpose of making a comparison of the use of the highways and benefits derived by different types and sizes of passenger vehicles, together with a study of their contribution to the maintenance of the highways.

This study has brought out some facts which can have a bearing upon the determination of equitable motor bus taxation. Among the most important of these facts are the following: A fixed rate of taxation per vehicle, based on weight or value or upon any combination of the two, does not furnish a method of taxation which is in any sense a measure of the use and benefits derived from the highway.

Gasoline consumption is a measure of highway use only when applied to a single type and weight of vehicle operating at a fixed rate of speed over the same quality of highway surface.

The gasoline consumption increases with the speed of the vehicle after the engine has reached a point approaching its maximum efficiency.

The gasoline consumption decreases as the quality of the highway improves, therefore the poorer the highway the higher the charge for its use.

The gasoline consumption per ton-mile of use of the highway decreases as the weight of the vehicle increases, thus imposing a penalty upon the owner of the lighter vehicle.

Notwithstanding the shortcomings of the gasoline tax (which are not generally understood) as a measure of highway use, such opposition to this form of taxation as seems to exist is due chiefly to the manner in which the proceeds of the tax are distributed for highway improvement rather than to dissatisfaction with this particular method of taxation.

Main Street of the East.—Virginia has recently opened a 204 mile section of U. S. Highway No. 1, the historic "Main Street of the East," extending the full length of the original 13 colonies. It begins at Fort Kent, Me., and follows the Atlantic Coast through Boston, New York, Philadelphia, Washington, Richmond, to its southern terminus, Miami, Fla. The total length is 2,300 miles.

Gravel Road Treatment with Calcium Chloride in Michigan

Extract from Paper Presented at 14th Annual Purdue Road School

By A. L. BURRIDGE
Division Engineer, Michigan State Highway Department

THE dust nuisance on gravel roads is something on which the public has become very critical and in many instances this criticism has become so intense that a perfectly good gravel road has been replaced by a more expensive type of pavement wheras if it had been properly cared for it would have served the traffic for many years. In Michigan we are preserving our gravel roads by treating them with bituminous tar and asphalt material and calcium chloride. During the coming year we will place calcium chloride on 3,430 miles of trunk line gravel roads at a total expense of $952,000. This seems like a lot of money, but when you consider the convenience this type of maintenance affords the public and when you consider that you save enough resurfacing gravel which is ordinarily blown away or shoved off the road to almost take care of the cost of this chloride, the expenditure is more than justified.

Before a road is treated with any surfacing material it should be brought to an even cross section thoroughly consolidated and the proper drainage established. We find ¼ in. to the foot crown to be sufficient. If loose gravel exists, binder should be added to the extent of from 8 to 12 per cent. Loose gravel and excessive crown causes the concentration of traffic. Concentration of traffic makes ruts. Even distribution of traffic over the entire width of your roadbed prolongs its life and decreases maintenance costs. If it is found impossible to consolidate all of the gravel in the roadbed, loose material should be bladed to the sides of the road and left there throughout the summer season. Calcium chloride will not consolidate a gravel that does not contain a certain percentage of binder and it is a waste of money to make this application unless the roadbed has been properly prepared before hand. We find that 5 tons of chloride per mile is sufficient for the first application. This application is made about the first of June and later in the season two or three tons are added per mile as the conditions of traffic and weather may demand. We find that on the ordinary road 8 to 10 tons of calcium chloride will keep your surface in a dustless, compacted condition throughout the year. In applying this chloride we use a 3½-ton truck to which is attached a standard chloride spreader or drill. We find it desirable to have this drill equipped with pneumatic tires carrying a pressure of 20 to 30 lb. In order to get the greatest benefit from the chloride treatment, the same should be evenly distributed upon the surface and this equipment allows us to accomplish this purpose. The 3½-ton truck is kept supplied with calcium chloride by small trucks which bring the material from cars at different points on the road and the same is transferred from the smaller trucks to the distributor truck. After calcium chloride has been on the road for one day we need to start floating our surface with a tractor-grader or truck equipped with a spring blade attachment. The road is first floated out and the blade is set so that it cuts the surface just enough to eliminate any chatter bumps that may have come into the road. This gives us a very small ridge of calcium chloride material which can be floated back on the road within the next day, or two or whenever the same is necessary. On heavy traffic roads we have found that it is necessary to float a road daily, but in many cases we have been able to keep this surface in good condition by floating only two or three times per week. The dead material which is floated out before the road is treated should never be floated back or brought into the road surface during the floating season, but it is desirable that this material be floated on to the road during the late fall and the same consolidated into the surface. Calcium chloride costs us about $30 a ton applied on the road. In case a 10-ton application is necessary this work will cost about $300 per mile per year.

To Color Pavements Green in Texas

Concrete roads which will blend in with the green fields and countryside soon will greet the eye of motorists traveling through Cameron county, Tex., if experiments now being conducted prove successful.

An issue of $6,000,000 of bonds recently was voted by the county for concrete highways, and it is planned to mix a green coloring fluid with the paving material. This will eliminate the glare resultant from the present white or gray roads. Experiments now being conducted will determine the amount of coloring fluid needed as well as the cost it will entail.

Cameron county is located in the extreme southern part of the Lone Star state and, it is believed, the color will harmonize well with the rich semi-tropical verdure and growing crops of the region which the roads will traverse, the promoters of the novel idea declare.

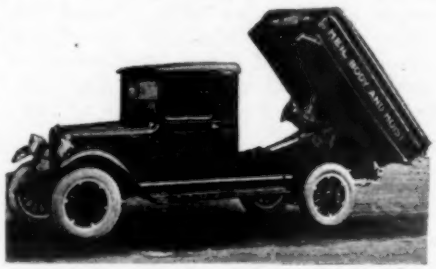
From an artistic standpoint, the green colored highways also will have an appeal that is not found in the white or drab colored pavement it is asserted.

Heil Hydraulic Hoists on Light Trucks

Up to the present time operators of light duty trucks had to depend almost entirely upon hand hoists and gravity dumps. Now, with the new H-2 Heil Hydro Hoist placed on the market, these operators can have light duty power operating dump equipment that has the same advantages as the heavy duty dumpers.

A dumping angle of 56 degrees is possible and the hoist will dump a full load in 5 to 9 seconds, depending on the speed of the motor. The racking of the truck body and frame, prevalent with gravity dump units, is entirely eliminated. The H-2 Heil Hoist is speedier than the hand hoist and eliminates the necessity of hand power to dump the load.

It is not necessary to refer to blue prints or to bore holes in the truck frame to install the hoist, as it comes assembled as a unit on a special sub-



Heil H-2 Hydraulic Hoist on Chevrolet Chassis

frame ready to mount on the truck chassis. Only four U-bolts are needed to fasten the hoist to the chassis. The danger of a wrong mounting is impossible with the Heil Hoist because it is already mounted on the frame.

With an H-2 Heil Hydro Hoist installation it is also possible to use the truck for other purposes, as the four U-bolts can be taken off in a few moments and the body and hoist removed, so that a tank or commercial body can be put on.

It is claimed to be the only light duty hoist that can be disconnected from the lifting arms. One man can disconnect and tip it back against the cab out of the way so that any part of the hoist can be easily inspected.

The H-2 Heil Hydro Hoist is said to be a powerful, self-contained, compact, accessible and speedy unit. It has the same gear principle used in Heil's heavy duty units, is thoroughly tested to several times its lifting requirements before leaving the Heil factory and will easily carry a 6,000 lb. pay load. Its simplicity of design with only two revolving parts make it easy to inspect and repair. Its long life with uninterrupted service and its reasonable price, say the manufacturers, eliminates the necessity of the light duty truck operator having to depend solely on gravity and hand dump units for trucks up to 2-ton capacity.

Highway Maintenance by Contract in the Province of Quebec

Specifications and Contracts Covering Maintenance Work

IN THE spring of 1925 the Minister of Roads of the Province of Quebec, Canada, began the experiment of maintaining provincial roads by contract. Most of the contracts covered the maintenance of those graveled sections of a certain number of highways, a total of 562 miles, being awarded the first year. This work was undertaken as an experiment with a view to ascertaining the best means of securing economy and efficiency in the maintenance service. The great difficulty in the road maintenance organization is to exercise over the maintenance men who are scattered in small units all over the province, that close supervision so necessary to produce the desired maximum of efficiency and economy.

Mr. Alexander Fraser, Chief Engineer of Provincial Roads, advises us that in a few cases they have been satisfied with the maintenance by contract experiment, but in a general way, however, they did not get the expected results and consequently are abandoning the policy by canceling a few of the contracts every year. Mr. Fraser summarizes the reasons for the failure of this plan as follows:

1. Lack of interest on the part of certain contractors in showing good results.

2. Difficulty of control of the quantity and quality of materials and workmanship.

3. Frequent misunderstanding between the contractors and the government engineers arising out of different interpretations of those provisions of the contracts applying to certain classes of maintenance work about which it was practically impossible to give indisputable definition.

4. No economy and no better practical results obtained.

Although the Quebec experiment has not proved exactly a success, the form of contract and the specifications, outlining as they do the maintenance methods, should prove of interest and they accordingly are reprinted below.

TENDER

I, the undersigned, do bind myself to perform all the works call for by the specifications dated ..... concerning ..... and this in the manner required by this specifications.

I do also bind myself to perform all the other works, which though not specifically mentioned in the specifications, might be required in order to execute the work undertaken, in conformity with the intention of the specifications.

As the only remuneration for all these works, should the Minister of Roads not require the use of calcium chloride, I would have the right to receive the lump sum price of $..... for each year of the duration of the contract and over and above that, the price stipulated for oiling when that work will be required.

Should the Minister of Roads require the use of calcium chloride, I would have the right to receive the lump sum price of $..... for each year of the duration of the contract, and over and above that, the price for oiling when that work shall be required.

The contract formed by the acceptance of the present tender shall be governed by the general specifications hereto attached.

In submitting the present tender, I declare that I have studied the said general specifications, other specifications, plans, profiles and sketches relating thereto, inspected the site of the work, and have secured sufficient information to enable me to establish the list and lump sum prices.

Date .....
Signature .....
Address .....

GENERAL SPECIFICATIONS

Definition

1. In the contract, in the tender, and in the specifications, the following terms shall be interpreted as follows:

The term "Government" means the Government of the Province of Quebec.

The term "Minister" means the Minister of Roads of the Province of Quebec.

The term "Engineer" means an engineer of the Department of Roads of the Province of Quebec, authorized by the Minister to direct and oversee the work covered by this contract.

The term "specification" means the special specification completed by one or more general specifications attached.

Lump Sum Contract

2. The contract resulting from the acceptation of the tender is a lump sum contract. Consequently, in consideration of the total price mentioned in the tender, the Contractor is held responsible for the performance of all the work described in the specification on which the tender was called for, and all other work whether mentioned in the specifications in the price list or not may be required for the performance of the work, in conformity with the intent of the specifications.

3. The list of prices contained in the above tender shall be used in order to prepare the monthly estimate, but the Minister of Roads shall have, at any time, the right to withhold from said estimates, besides the deductions provided by the specifications any amount he may deem necessary in order to guarantee the complete execution of all the works required.

4. The Government shall never be compelled by virtue of any clause of the present contract to pay to the contractor more than the total amount mentioned in the tender.

Other Obligations of the Contractor

5. The contractor must supply all that is required, labor, materials, tools, machinery, and appliances necessary for the proper completion of the work.

6. The work shall be performed in conformity with the specifications, and in a workmanlike manner, with materials approved by the engineer, the use of which has been authorized by the Minister.

7. The contractor shall have the technical knowledge required for the performance of the work undertaken.

8. The contractor shall not, without the consent of the Minister, transfer or assign his contract or have the work performed by subcontractors. He is personally responsible to the Minister, to the workmen and to the public.

9. The contractor is solely responsible to the workmen and their families, for accidents that happen during the performance of the work.

10. The contractor is solely responsible to the public for all damage caused by the work of which he controls the performance.

11. The contractor has not the right to begin the work before having received the order from the engineer, but as soon as he has received that order, he must, without delay, take the necessary steps to have the work prosecuted with diligence.

12. If the contractor refuses or neglects to take the necessary means for the carrying out of the contract, or should he, after having started the work, fail to carry it out with sufficient diligence, or should he not make the repairs required by the engineer, or should he become incapable of continuing the work, or neglect to pay the wages of the workmen, the Minister can, without formality, take over the work and have it performed at the expense of the defaulted contractor. In this case, the amounts earned by work done, the holdbacks on payments, and the guarantee furnished by the contractor become the property of the Government and may be used to pay for damages caused by the contractor's default, without prejudice to the government's claim against the contractor in case of the insufficiency of the above amounts.

13. All work not done according to the plans and specifications must be done over by the contractor, at his own expense.

14. Over-seeing and approval by the officers of the Department will not free the contractor from the obligation to do the work strictly in accordance with the specifications and plans, and in a workmanlike manner, nor from the obligation of having a competent man constantly in charge of the work.

15. The approval of materials, or the stipulation in the specifications of the use of material coming from a designated source, shall not free the contractor from the obligation of furnishing materials of a quality required to do good work.

16. Unless authorized to do so by the Minister of Roads, the contractor has no right to put any inscription on the works performed.

17. The contractor has no right to appropriate to his own use material coming from the demolition of a bridge or other work.

18. The contractor shall look after the work so that at all times there will be a safe passage for the public; he shall indicate clearly, by day and night, excavations and dangerous places, in order to prevent accidents; he shall also build, and maintain in good order, temporary bridges and diversion roads; secure, when it is necessary, a right of way over the adjoining properties for the diversion of the traffic, during the time of construction.

19. The contractor, when he has finished his work, must clean it up and put it in good order; remove all waste and unused material or scrap; clean up the spots where earth or other materials have been deposited; put in good order the ditches and streams which he may have obstructed, and repair or rebuild the fences which he may have damaged or demolished; he must repair all other damage he has caused.

Payment of Workmen's Wages

20. Should he be informed that a workman employed on the performance of any work covered by the present contract has not been paid the wages due him, the Minister, eight days after having notified the contractor by letter, mailed to him at the address given in the tender, may acquit the workman's account, from the contract price or from the guarantee deposited by the contractor for the complete performance of the contract.

21. If within the aforesaid period of eight, the contractor protests the account, the Minister has not the right to acquit the account until the workman's claim has been established in court of justice. Nevertheless, the Minister can retain an amount which he considers sufficient to acquit the account, in case it becomes recognized as being well-founded.

Purchase of Materials

22. At the request of the contractor, the Minister may buy the materials necessary for the performance of the works, and pay for them out of the contract price.

Payment of the Contract Price

23. Payment to the contractor for the work done during one month will be made during the following month, after a deduction has been made for the price of material bought by the Minister, and for the holdback.

Value of Work Done

24. At the end of each month, the engineer will establish the value of work done by the contractor, using as a base the amount of wages paid and material purchased by the latter. To this end, the contractor must communicate to the engineer the payroll of all his employees, and all the information required by the engineer.

Holdback

25. At the time of payment a holdback is made of ten per cent (10%) of the value of

work done; this holdback will be paid to the contractor in the month of December of the year in which the holdback was made, provided the contractor has not failed in any clause of the contract.

26. Over and above the holdback of ten per cent (10%) the Minister of Roads can make any other holdback which he considers necessary to guarantee the execution of the contract.

Preparation of the Tender

27. The tenderer should submit a lump sum price for all the work; furthermore, he should submit a unit price for each kind of work, in the space reserved for that purpose in the specifications.

28. The contractor must establish his prices according to information he has himself secured. He must verify the exactness of all information given to him by officials and clerks of the Department of Roads and has no right to any indemnity or recourse if he undergoes any damage for having depended upon information which later he finds out to be incorrect.

Composition of Specifications

29. A list indicating the quantity of each kind of work to be done follows the specification. The tenderer should submit a unit price for each kind of work designated in this list.

30. The plans, profiles and sketches referred to in the specifications, form part of the specifications as though they were fully contained therein and complete same. The contractor who submits a tender is supposed to have secured the plans, profiles and sketches and to have examined and studied them.

31. All dimensions mentioned in the specification shall be measured according to the English units (articles 14, 15 and 16 of the 52nd chapter of the Revised Statutes of Canada, 1906).

32. When, by the particulars of the specifications, the engineer is authorized to give an order, this order will be valid only when given by means of a writing signed by the engineer.

SPECIFICATION

Bituminous Products Treatment

The term "gallon" in these specifications means the standard gallon of Canada as defined by Article 20 of the 52nd Chapter of the Revised Statutes of Canada, 1906, and it's the same as the English Imperial gallon. This gallon contains 277.274 cubic inches. (The American gallon, or standard gallon of the United States, contains 231 inches.)

Preparing the Macadam

The whole macadam surface to receive bituminous treatment shall be carefully scraped and broomed in such a way as to leave the stone bare, and shall have as perfect a mosaic appearance as possible. All dust and foreign matters proceeding from this cleaning of the macadam shall be spread over the shoulders. Two men with the use of metallic brooms shall keep ahead of the spreading party to make sure that no animal, vegetable or other matters remain on the surface.

The treatment shall consist of one-sixth (1/6) gallon per square yard.

It is of main importance that all traffic be diverted for at least such a time that will allow the penetration of the bituminous product. Where and whenever this is not possible, it will then be advisable to only cover one-half of the surface along the road, at a time.

After the application of the bitumen, there shall be spread a very thin cover of clean, hard and sharp angular sand. Once the hardening of the bituminous material has started, it shall carefully be broomed by means of vegetable fibre brooms.

These applications shall only be made over a clean, dry, and whenever possible, a sun-heated surface.

SHERBROOKE-DERBY-LINE HIGHWAY

Maintenance Specifications—First Part

Total length, from mile 3.61 to mile 33.87 ..... 30.26 m.

Section No. 1 from 3.61 to 8.11 macadam	4.50 m.
Section No. 2 from 8.11 to 15.80 gravel	7.69 m.
Section No. 3 from 15.80 to 24.00 gravel	8.20 m.
Section No. 4 from 24.00 to 32.55 gravel	8.55 m.
32.55 to 33.87 macadam	1.32 m.
Total	30.26 m.

Contract Durance—From January 1st, 1925, to January 1st, 1930.

Preliminary Work in the Spring

As soon as the spring thaw begins, the contractor must remove from the culverts all snow and ice that would interfere with the flowing of the water, and make such trenches in the snow, either on the road or in the ditches, as may be necessary to direct the water into the ditches and prevent it from running over the road.

When the road is opened to summer traffic, the contractor must at once take the necessary steps to prevent any damage arising from excessive use of the shoulders or of any narrow part of the road surface by such traffic. The cuts which the municipalities may have made in the snow to open the road must be widened at the necessary places to permit the traffic to operate on a surface at least 14 ft. wide, and at the places where the snow is lying in drifts on one side of the road, obliging the vehicles to pass on the side of the road where the layer of gravel is thin, or on the shoulders, this snow must be removed on each side of the center of the road to a distance of 7 feet.

Repairs to Parts of Road Damaged by Frost

At the places where bog-holes appear, they must be filled immediately with good gravel containing no stone of more than 1 inch in size on its largest dimension. The surface of the road at these places must be leveled each time gravel is added and as often as required during the settling of the latter in such a manner as to maintain the regular crown and longitudinal profile of the road.

Surface Drainage

The ditches shall be cleaned and dug wherever necessary.

Cleaning of Culverts

The culverts and their outlets shall be cleaned wherever necessary, the total number being as follows:

Section No. 1	17 culverts
Section No. 2	26 culverts
Section No. 3	20 culverts
Section No. 4	13 culverts

Cutting Hay, Weeds and Brush

Section No. 1	19,370 ft. x 6 ft. both sides
Section No. 2	41,025 ft. x 6 ft. both sides
Section No. 3	43,296 ft. x 6 ft. both sides
Section No. 4	45,144 ft. x 6 ft. both sides

Regardless of the average widths given above, the cutting of hay must be carried as far as the fences on both sides of the road twice during the season, during the last half of June and the last half of August, unless the engineer decides otherwise. The hay must be cut to the bottom of the ditch and the cuttings removed beyond the limits of the road. Brush and weeds must be cut and destroyed in accordance with the regulations of the Municipal Code.

Maintenance of Graveled Shoulders
(On the macadamized section)

Section No. 1, from 3.61 to 8.11 m., 23,760 feet, both sides.

Gravel to be added wherever necessary to keep the inside edges of the shoulder level with the macadam, and to maintain a regular slope of not more than one and one-half inches to one foot towards the ditches. The gravel shall be spread and leveled evenly and it shall not contain stones larger than one inch in size.

Repairs to Guard-Rails

Guard-rails to be repaired wherever necessary.

The total lengths on each section are as follows:

Section No. 1	4,390 lin. ft. of guard-rail
Section No. 2	536 lin. ft. of guard-rail
Section No. 3	3,056 lin. ft. of guard-rail
Section No. 4	272 lin. ft. of guard-rail

In repairing guard-rails, the contractor must replace all broken or damaged posts or other pieces. The lengths given above are the total lengths of gurd-rails.

These repairs should be made before the painting.

Painting of Guard-Rails

The painting of guard-rails shall be done during the months of May and June.

The guard-rails shall be painted with one coat of paint duly approved by the engineer, at least once every two years and more often if necessary.

Section No. 1	4,390 lin. ft.
Section No. 2	536 lin. ft.
Section No. 3	3,056 lin. ft.
Section No. 4	272 lin. ft.

Repair and Maintenance of Danger, Direction and Other Road Signs

Municipal boundary posts, mile posts, boards indicating the speed limits, and all the danger and direction signs (including posts, boards, frames, metallic sheets, etc.) shall be repaired or replaced as soon as they have been damaged or removed.

The approximate quantities are as follows:

Section No. 1	6 mile posts
	3 direction posts
	1 speed limit post
	20 danger signs, including
	4 railroad crossing signs
Section No. 2	7 mile posts
	20 danger signs, including
	4 railroad crossing signs
	2 school signs
Section No. 3	9 mile posts
	8 danger signs, including
	2 school signs
Section No. 4	9 mile posts
	2 direction signs
	1 speed limit post
	8 danger signs, including
	2 school signs

Painting of Danger, Direction and Other Signs

All the signs indicated under the head of repair of signs must be painted with one coat of paint approved by the engineer at least once every two years, and more often if necessary.

This painting should be done during the months of May and June, if possible.

Whitewashing of Telephone, Telegraph and Power Transmission Poles

Section No. 1	594 poles
Section No. 2	615 poles
Section No. 3	660 poles
Section No. 4	800 poles

The poles shall be whitewashed uniformly to a height of 5 ft. above the ground line, twice during each season, according to the instructions of the engineer. (The line between the whitewashed part and the part not whitewashed should be cleaned and regular.)

General Remarks

The number of culverts, posts and signs, the lengths of guard-rail, etc., are approximate and might be increased slightly. The contractor must make all the repairs, and do all the painting and whitewashing, whatever the number of culverts, posts, signs, etc., and whatever the lengths of guard-rails, etc., there are at present or there may be during the time of his contract.

Maintenance of the Graveled Roadway, Dragging, Addition of Gravel and Ordinary Maintenance of the Roadway

The dragging of the road shall be done sufficiently often to keep the road free from holes, ruts, depressions, cross-waves, etc., and in any case at least twice a week from the beginning of the season to July 1st, and from September 1st to the end of the season. During July and August, the road shall be dragged at least three times a week. By dragging is meant the passing of the drag both ways at least three times.

The drag employed shall be of a type approved by the Minister of Roads and accepted by the engineer.

Stones larger than 1 inch shall be removed from the surface of the road as soon as they appear. These stones must not be left in piles or rows on the edge of the road, but must be removed beyond the limits of the road without undue delay.

Additional gravel must be placed on the road where indicated by the engineer in such a manner as to keep the regularity of the surface and the present thickness of the layer of gravel. The minimum quantity of additional gravel required to achieve this result is 150 cu. yds. per mile per year.

This gravel shall be spread on the sides of the road, in conformity with the engineer's instruction, to be dragged gradually towards the center of the road in thin layers. The gravel shall be screened at the pit, so as to remove the stones of more than 1 inch in size.

Furthermore, the contractor is obliged to fill with gravel the holes, ruts or depressions that may occur in the spring at the time the thaw sets and the holes and ruts that may occur here and there in the course of the season. The gravel necessary for this work will be in addition to the quantity mentioned above.

Maintenance of the Macadamized Road Patching With Hot Bitumens (Mastics)

1. Filling holes, ruts, depressions and cracks, and patching of the edge of the pavement along the shoulders.

The road shall be thoroughly cleaned; the bitumen shall be heated to the proper temperature and then poured into the holes, ruts, depressions, etc., in sufficient quantity to fill the voids of the stones necessary to fill the holes, the voids in the stone to be reduced to the minimum by tamping. The stone shall be placed immediately after the bitumen. It shall be well tamped except where the depressions are less than 1 inch in depth.

In cases where the holes, ruts or depressions are deep, the repair shall be made in two layers, tamped separately. Ordinarily, for the lower layer, the stones may be from ½ in. to 1 in. in size. For the upper layer or for a single layer in the case of light depression, the stone shall be from ¼ in., to ½ in. in size. In general, the size of the stone shall be such that the thickness of the layer after tamping will be twice the size of the stone used. In the case of repairs made in more than one layer, the upper layer shall have a thickness of ¾ in. to 1 in., with stone of ¼ in. to ½ in.

Repairs to Rough Surfaces

The surface shall be thoroughly swept to remove all dirt and loose stones and pieces of bitumen that did not adhere to the macadam. A light layer of bitumen binder shall them be spread, after having been heated to the proper

temperature and covered immediately with a layer of small stones ½ in. to 1 in. in size, in sufficient quantity to absorb the bitumen. Care must be taken that the bitumen is not applied in excessive quantity, as that would occasion the formation of a wavy surface under traffic.

Repairs With Cold Bitumens

Repairs to holes, ruts, depressions, cracks and the edge of the pavement along the shoulders, can be with cold bitumen in the following manner:

The cold bitumen shall be mixed with stones of appropriate size, according to the depth of the holes, ruts, or depressions, in the proportion of 12 to 15 gallons to a cubic yard of stone, then adding same level as the surrounding pavement.

All the bitumen used shall comply with the specifications of the A. S. T. M.

The lengths and widths of macadam pavements to maintain are as follows:

Section No. 1 from mile 3.61 to mile 8.11, width 14 ft.

Section No. 4 from mile 32.55 to mile 33.87, width 16 ft.

It is understood that the dimensions, quantities, and details given above are approximate, and only to give general ideas to the contractor, the latter shall at all times take all the steps necessary to maintain the road in good condition, and shall perform all the work in an orderly manner, according to the spirit of these specifications and to the best known methods.

Calcium Chloride

On graveled sections, should the Minister consider it advisable, an application of calcium chloride shall be made at the rate of 1 pound per square yard on a width of 15 feet once during the season. When making this application, there should be a thickness of about 1 inch of loose gravel on the surface of the road; this may be obtained by loosening the surface or by adding gravel.

Application of Bituminous Oil Asphalt, 50 Per Cent or Its Equivalent

On the macadamized road, the contractor shall make an application of bituminous oil at the rate of 1/6 gallon per square yard with sand in conformity with the attached specification for the application of bituminous materials.

This application shall be made every two years, the first to be made in 1926; so that there will be two such applications made during the term of the contract.

This oil shall be applied during the month of June.

The price for oiling shall cover all the work pertaining thereto, as indicated in the attached specifications for the application of bituminous materials.

Quebec, February 20th, 1925.

.....
Principal Engineer,
District No. 2.

.....
Chief Engineer.

TENDER

All the works mentioned in the present specification shall be done at so much per year per mile of macadamized road, and so much per year per mile of graveled road for the duration of the contract.

For the graveled part, it is necessary to submit a price for each case, with or without chloride.

In the case where an application of calcium chloride is specified, the price for maintenance independent of the calcium chloride, and the price for the chloride applied, shall be submitted separately.

The contractor must use the materials previously bought and stocked by the Department, the latter holding back the buying price of same from the contract price.

Macadamized Section

5.91 miles @.....per mile .....
8,225 gallons of Bituminous oil,
per application @.....per gallon.....

Graveled Section

1st case (without chloride application)
24.44 miles @.....per mile.....
2nd case (with chloride application)
24.44 miles @.....per mile.....
107.54 tons of chloride applied @
.....per ton.....

Methods of Payment

Date.....
Signature.....

1928 Model Russell Motor Patrol

The illustrations on this page show the Russell Motor Patrol No. 4 powered with a 2-ton "Caterpillar" tractor and the Russell Motor Patrol No. 3, powered with a 10-20 McCormick-Deering tractor. Russell also builds two other models for the Clertrac and Fordson tractors.

The 1928 model Russell Motor Patrols are not a drastic departure from our last year's model. The general construction is the same, but there are numerous improvements which insure efficiency and low upkeep cost.

The principal improvements are:

Compensating spring lift;

Main circle reinforced;

Large universal connection at front of drawbars which eliminates all play;

Grip lock nuts on all bolts ⅜ in. to ⅞ in., inclusive, that will positively not come loose from vibration;

Heavy channel frame, 8 in., 21¼ lbs. per foot;

Enclosed machined cut gears for blade and scarifier lift;

Ball and socket connections, and

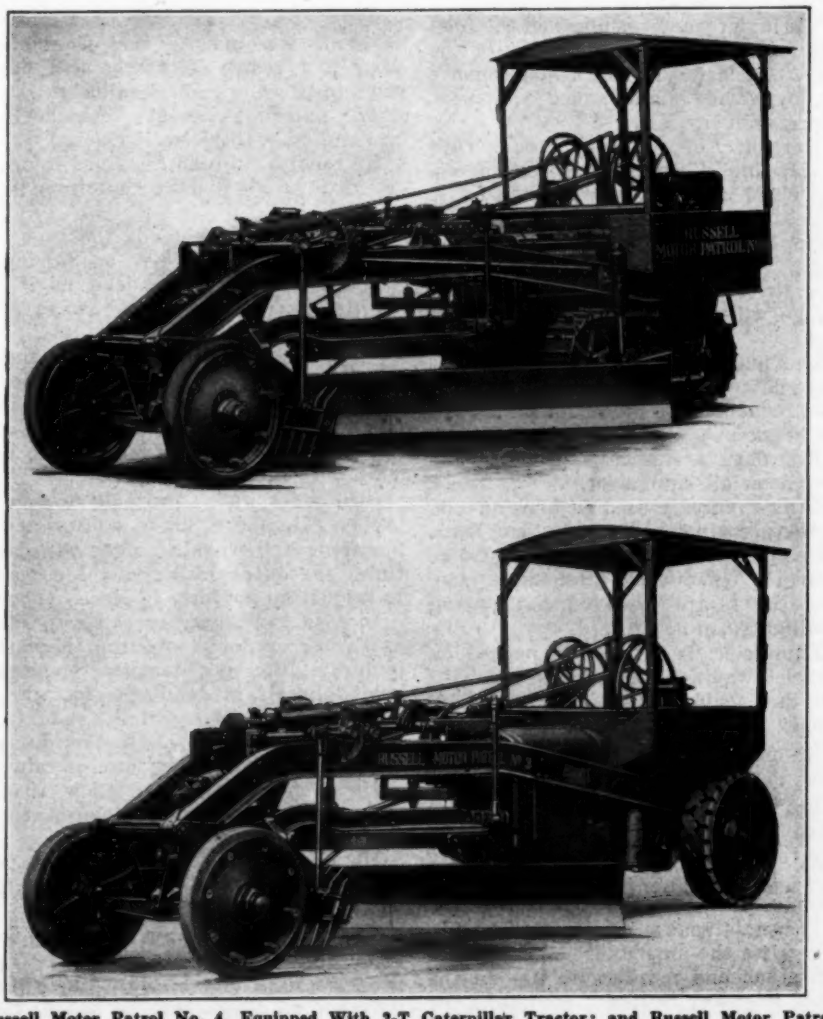
Moldboard reinforced by two angle irons.

In addition there are many other outstanding features found on the Russell Motor Patrol which are worthy of mention as listed below:

The Scarifier is independently adjustable and completely controlled from the operator's platform. The front wheels are 32 in. by 5 in., with extra wide axle to accommodate the larger wheels.

There are bronze bushings and bronze collars for worm shafts; take-up bearing in forward lifting arm bracket; the center shift operated by a worm and gear through a rack and pinion; circle play is eliminated by means of a screw clamp in circle brackets; machined worm gear steering control, steers as easily as any truck; Alemite lubricating system throughout; Timken bearings are used in front axle; a side crank for tractor is furnished as regular equipment; and a steel cab that may be entirely enclosed.

The Russell may be made an all the year around machine by the addition of a Russell Snow Plow Attachment. The weight of the Russell Motor Patrol No. 4, complete with tractor and scarifier attachment, is 12,500 lb. The weight of the Russell Motor Patrol No. 3, complete with tractor and scarifier attachment, is 12,550 lb.



Russell Motor Patrol No. 4, Equipped With 2-T Caterpillar Tractor; and Russell Motor Patrol No. 3, Powered With 10-20 McCormick-Deering Tractor

Safety—The Maintenance Patrolman's Pledge

Some excellent suggestions for patrolmen are given in a recent "Roadio" News of the Missouri State Highway Department. The article prepared by T. H. Cutler, Chief Engineer, follows:

Safety on the highways is dependent upon the efforts of the individual.

Safety is a matter of education of the individual.

It matters not how permanently a road is located or constructed, without proper maintenance, elements of unsafety will rapidly multiply and eventually the road will become a loss, or reconstruction will become necessary with all the intervening inconveniences to the road users.

Maintenance work is a branch of highway endeavor wherein the individual plays the most prominent part, and his value to the organization becomes greater with his continued employment.

In maintaining the 7,640 mile state road system of Missouri, it is necessary to employ approximately 850 men. The perfecting of this maintenance organization, necessary for the successful execution of the maintenance work, has been a task requiring patient and persistent cooperation of all employees.

The maintenance men are on the road continuously every working day of the year. Accidents in which maintenance employees and maintenance equipment figure are very few.

The policy of using considerable care in choosing all maintenance employees, has given us men endowed with faithfulness to duty, and who realize their responsibilities for safety on the highways.

A strict observance of the following pledge will insure a good safe patrolman:

The maintenance patrolman always keeps his equipment in good condition, thus reducing to a minimum the chance for breakdown on the highways.

Red flags are always properly displayed on all equipment.

Utmost care is used in backing and turning equipment; efforts are made in stopping, to not cause a traffic hazard. When used after dark, adequate lights are displayed, but glaring headlights are never used.

Equipment is never left parked on traveled way after day, unless attended by the maintenance employee with proper lights and signals.

No one, other than a state employee, rides on the maintenance equipment.

Proper signals are always given when stopping or turning, and attention to approaching traffic from county roads, lanes, or private drives, is always given.

The maintenance employee thoroughly realizes the importance of the standard signs and markers in use on the State Highway System. He knows the designs as now used are based on definite principles calculated to produce uniformity of significance in the signs themselves, and make familiarity with them easy to acquire.

He is duty bound to never go by a highway marker, directional sign, caution sign, or information sign that is down or out of position.

Just the opposite to this, he must keep all advertising signs off the right-of-way, as they direct attention of the users of the highways and are unlawful on the highways.

Warning flags, caution signs, men at work signs, are always properly displayed when there is work in process by the maintenance men.

Bridges are kept in good repair and properly painted both for safety and economy.

Special attention is always given to bridge floors.

Bumps at bridges are not allowed to develop.

Approaches to bridges are maintained in good condition.

Guard rails on high bridge approaches are always given special care.

Guard rails are erected at all hazardous places and kept properly painted and repaired.

Maintenance equipment is never stopped on a railroad track.

After crossing a railroad track with dragging equipment, the patrolman stops and clears off tracks and flagways to prevent train derailment.

The patrolman always looks before crossing over all railroad tracks.

He reports railroad crossings in need of repair to his district superintendent at once.

Snow removal demands the time of the maintenance employee on Sundays, holidays and nights as long as it is snowing, and until the highways are open.

"Keep traffic moving" is the snow fighting slogan, and all maintenance employees are up and at snow removal from the first snowfall. It does not pay to wait until it is too high to remove with the equipment.

Barricades are properly erected, properly lighted at night, and properly placated with warning signs for daytime. Frequent inspections are made to keep them properly in place.

In case of disaster or calamity such as storms or floods effecting the state highway, the maintenance employee holds himself in readiness for group duty any place, at any time.

He always patrols his section during or immediately after a storm or rain.

He properly marks overflow roads, staking them out before the floods reach the road.

He assumes the lion's share of the responsibility of trying to protect traffic during such times.

The patrolman always keeps himself physically fit for duty, he never appears on work intoxicated or under the influence of drugs, and he has proper clothing for his work.

He treats the small cuts and bruises he receives at once, to eliminate the possibilities of blood poisoning.

He does not have defective hearing or eyesight.

He is never absent from his work, unless proper provisions have been made.

He renders assistance to accident victims, helps clear wrecks so as to eliminate danger to the other users of the road.

Slab pavements must be center-stripped to guide traffic.

Care must be used in placing loose gravel and warning signs must be used while gravel is packing.

Ruts must not remain next to slab pavements.

Blow-up in slab pavements must be placated with warning signs at once, and repairs made as soon as possible.

Efforts should be made in maintain-gravel roads, to not leave a windrow of loose gravel in road after quitting time. Long stretches of windrowed gravel at no time should be found.

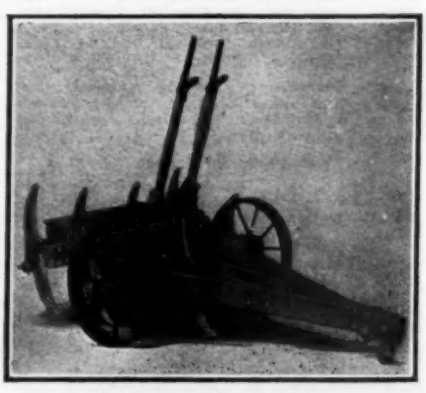
The state highway maintenance patrolman things about the safety and convenience of the road users.

He is a "Safety First" adherent, and realizes that it is far better to be safe than sorry.

Lakewood Puts Out Improved Graderooter

The Lakewood Graderooter for 1928, manufactured by the Lakewood Engineering Company, Cleveland, Ohio, is equipped with double pointed teeth made of high grade steel, one inch thick instead of single pointed teeth three-quarter inch thick, as previously used. The teeth can be set to root twelve inches deep and forty-eight inches wide. Ten teeth are furnished with each machine.

The Graderooter is used wherever a rooter plow can be employed. A particular advantage is that it will work close to the forms. It is light enough to be pulled by teams and strong enough to stall the heaviest tractor. The Graderooter is also used for maintenance work by the State and County Highway Departments.



The Lakewood Graderooter

Inspection and Construction Practices on Indiana Roads

Methods and Practices Followed on Work of Indiana State Highway Commission

By J. T. HALLETT

Assistant Chief Engineer in Charge of Roads, Indiana State Highway Commission

THE goal we try to reach in our work is to get the best possible work under the plans and specifications under which the contract is awarded. On state and federal work the plans and specifications are standardized so that the methods of construction and inspection are somewhat standardized and on which I will spend the most of my time. I, however, can not say that these take most of my time when on regular duty.

During the fiscal year of 1927 our department had supervision and inspection on 129 contracts. Fifty-eight of these were state and federal projects on which the specifications were very near but not exactly the same. The remaining 71 of these were county projects on which state inspection had been asked. They were in a number of different counties in the state and the specifications varied considerably. The only general rule which can be followed on inspecting county work where the specifications vary is to get the best possible under the specifications. This work, therefore, takes considerably more time to supervise than where the methods can be standardized.

Preparation of the Grade.—The first operation in building a concrete road and in fact any road is the building of small drainage structures and the preparation of the grade, that is, making the cuts and fills. I will not dwell on the construction of the drainage structures as they will naturally fall under another heading. I will only mention a few of the most important methods we follow in grade preparation and these hold equally as good for other types of roads as for concrete. First—the project engineer sets substantial stakes on or near the right of way line at each 100 ft. station and on each side of the road. These stakes are usually 2 in. square by 18 in. long dressed on two sides to facilitate marking the station numbers and the distances from the center line on them. Then elevations are taken on each stake and a grade sheet computed giving the distance the finished grade is above or below each stake. The grade foreman is furnished with a copy of the grade sheet or sheets with which he can level off and determine the cut or fill at each stake, before any earth is moved, bushes, trees, stumps and heavy sod are removed from the roadway. If there is an old grade which is too narrow it is torn down and spread out to

An Indiana Highway

full width of the base of the new fill. It is then leveled off and thoroughly rolled with a 10-ton 3-wheel roller. After this the fill is built up in layers approximately 1 ft. in thickness and each layer rolled as before. The back filling adjacent to culverts and bridges is placed in 6 in. layers and each layer thoroughly tamped by hand. Occasionally when a pump and plenty of water is available the back fills are puddled. The reason for all of this precaution in building the grade is to build a uniformly compacted grade and minimize the later and unequal settlement which as you all know is very serious for any kind of pavement, but its effect is much more noticeable on a concrete pavement than on a flexible pavement.

Preparation of Sub-Grade and Setting Forms.—The next step after construction of the grade is the preparation of the sub-grade commonly called fine grading. The smoothing up to get the grade within one or two tenths of the correct elevation is done with a blade grader and fresno, the fresno being better than scrapers or wheelers because they can pick up and deposit in very thin layers. Then form stakes are set to both line and grade 1 or 2 ft. outside of the form a line on each side of the road. These stakes are set at 25 ft. intervals. We have found that a much truer surface is obtained both as to line and grade if these stakes are set not farther apart than 25 ft. The foundation for the form is then prepared to exact elevation. If a slight fill is necessary the hand tamp is used to compact it. The usual method used in preparing this foundation for the forms is by hand, but some of the more progressive contractors have a form grading machine which is a great labor saver. As soon as the foundation for the forms is prepared the forms are set true to line and grade and firmly staked. Then the subgrade is completed between the forms to receive the concrete. This is sometimes done by hand but usually with a subgrader pulled on the forms with power and the blades are set to the required depth and cross section. A small roller of about 3 tons in weight is very useful in compacting and smoothing up a subgrade. On truck units where the concrete materials are hauled into the mixer by truck, it is sometimes a great advantage to do a large part of the fine grading at morning or night when the trucking does not interfere. Also where trucks are used, when the subgrade is prepared it does not stay that way as the trucks keep continually working it out of shape. This requires constant attention so there is no work to do on the grade when the mixer arrives. Here again the small roller with a bull-nozer blade is a very useful tool.

Of course with the industrial hauling outfit, when the sub-grade is once prepared it stays that way unless treads of the mixer push it out of shape. All sub-grade crews work to a template riding on the forms and the last thing before concrete is deposited the elevation and section of the sub-grade is checked with the template, and any irregularities corrected. After the subgrade is completed the uniformity of the grade of the forms is checked with a 10-ft. straight edge so any irregularities can be found and removed before any concrete is deposited against them. In order to obtain a smooth surface in the pavement it is very essential that the forms be accurately set and have a full bearing on a firm foundation. Any line of forms which has not an even bearing and firm foundation should be taken up, the foundation corrected and the forms reset. These methods of checking the forms and sub-grade make the workmen check their own work and greatly aids the inspection.

Placing of Center Joint and Reinforcing Steel.—After the sub-grade has

been prepared and the forms set, the center joint and reinforcing steel if there is any used, should be placed. The center joint should be placed accurately and firmly staked to line and grade by means of a template riding on the forms. If the center joint is not to correct line it looks bad on completed work, and if not to correct grade, it weakens the load transferring effect from one slab to the other, and the concrete is more likely to spall and start disintegration. All reinforcing steel or continuous dowels should be held in place by metal chairs left in place. We have had some sad experiences by using sleds to support reinforcing steel. When the sled is pulled out it tears a hole in the concrete, the concrete arches over and leaves honeycombed places which afterwards crack. No doubt some of you have noticed some of our pavement about three or four years old which has longitudinal cracks at the center and quarter points. In every case where you have noticed this and the major portion of the cracks run rather uniform, they were caused by the use of the sled for holding reinforcing steel. Care is used to see that all dowel bars are either painted or oiled to prevent bond between the concrete and the steel.

Inspection and Proportioning of Materials.—Before any material is used in the pavement the source of the material and the producing plant should be inspected to make sure they can furnish a uniform and satisfactory quality of material. Also the quantity is often quite important as continual changing of materials is often the cause for poor results. Uniform material properly handled will produce uniform results which is very essential in concrete work. To insure that all materials are satisfactory, each car of cement should be tested, each car of sand and coarse aggregate should be visually inspected and if there seems to be any doubt as to any of its qualities further tests should be made. Grading tests on the aggregate should be run on every five or six cars at least and oftener if necessary to insure the proper grade. Aggregates should be inspected while being unloaded and after unloading for dirty coated material. First class concrete can not be made from dirty and coated aggregates. An excess of stone dust on stone is as bad as mud or silt on gravel. We have found in some cases cars of aggregates when inspected from the top appeared in first class condition but for some reason the bottom of the car was not in first class condition.

The proportioning of materials is usually covered by the specifications. The common method is to proportion by volume assuming that 1 bag of cement is 1 cu. ft. in volume. The standard specifications have up to this time required an approximate 1:2:3 mix with a definite cement requirement of 1.7 bbl. to the cubic yard of mixed concrete. This of course requires adjustment of the proportioning of aggregates to get this cement content. It would take some time to go into detail on how and when to make these adjustments but in general the amount of cement and sand should be left constant and all adjusting made with the coarse aggregate. At the present time the state is specifying that the aggregates be proportioned by weight. This is the first time this has been specified by us and I have had no construction experience with this method. The most accurate and in general the most satisfactory method, both from the construction and inspection standpoint, of proportioning aggregates by volume, is by use of the automatic batcher boxes manufactured by a number of equipment manufacturers. Cement usually comes in bags and even bag batches are usually arranged for. Split bag batches are not very satisfactory in that it is next to impossible to get accurately the correct amount of cement in each batch. To make sure the correct number of bags of cement go in each batch the cement for the batch should be piled in a separate pile before any of the bags are emptied into the batch. If the bags are piled up they are very easily counted but if two or three men are emptying cement into a batch it is impossible for an inspector or even the men themselves to be sure just the number of bags used. If a plant inspector is not used the cement should come to the mixer either in the bags or in separate compartments so the inspector can check the amount of cement used at all times. If separate compartments are used care should be taken to see that they are tight and the cement does not lose out on the road between the plants and the mixer.

Mixing Concrete and the Consistency.—Concrete should be mixed with a standard make of paving mixer which is in good mechanical condition with a water control tank by which the amount of mixing water can be accurately measured. Leaky water valves should not be permitted. The paving mixer should be equipped with a timing or regulating device by which the discharge chute is locked until the concrete has been mixed for the specified time.

The consistency is controlled by the length of mixing and the amount of water used in the batch. Each concrete inspector is equipped with a slump cone. He makes slump tests at least once a day. For a machine finish the slump should be not more than 2 in. or les than ½ in. If it can not be kept within this range the reason is ascertained and corrected. For good results both from the standpoint of good concrete and correct finish the consistency should be as uniform as possible.

Depositing, Striking and Finishing of Concrete.—After the concrete is mixed it is deposited on the subgrade from the bucket and spread somewhat with shovels. It is then struck off with a mechanical finishing machine of which there are two types, the tamping machine and the screed. Each time over with the machine, concrete should be kept in front of the strike throughout its entire length. If this is not done it will likely result in uneven surface. The first time over with the screed machine the concrete should be allowed to pile up 8 or 9 in. high ahead of the screed, this is to allow the weight of the concrete to compact the concrete in the slab and take the place of tamping. The number of times it is necessary to go over with the finishing machine will depend on a number of factors such as per cent of grade, consistency, temperature, etc. Usually not less than two times will suffice and not more than three times is necessary. After the finishing machine has done all that can be done on finishing the surface, the surface is checked with a 10 ft. straight edge and any noticeable variations removed with a wooden float. Before the final belting a 10 ft. float is used transversely. This removes a great number of small ridges and variations in the pavement surface. Then again after the surface of the pavement has hardened sufficiently to walk on the surface is checked with a 10 ft. straight edge and any variations of ¼

A Recently Completed State Road Job

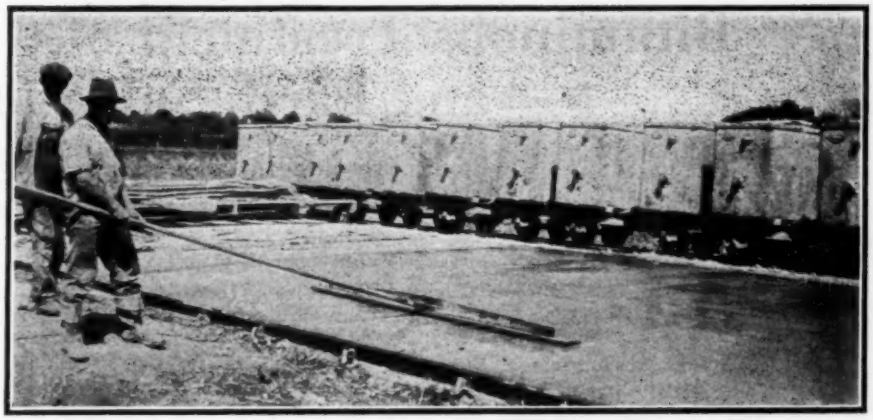
in. or more are removed with a carborundum brick and water.

Construction and Expansion Joints.—At the end of each day's run a butt construction joint is made. ¾ in. round dowel bars 4 ft. long, extending 2 ft. in each section of the pavement are placed. At least one end of these dowels is wrapped or oiled to prevent bond. If these bars are permitted to bond a transverse crack will develop about two or three feet from the construction joint.

Expansion joints are placed adjacent to bridges so as to relieve the bridge from taking the thrust from the pavement slab. We have had some serious affects on bridges when these expansion joints were omitted. Dowel bars through expansion joints do very little good but if placed the ends of the dowel bars should be capped so as to allow free longitudinal movement of the slab without buckling over the bars. Serious trouble may be expected if these bars are not capped.

Curing of Concrete Pavement.—Just as soon as the pavement has received its final belting and has hardened sufficiently to prevent marking badly, strips of burlap are placed on the surface completely covering it. The burlap is sprinkled with a spray nozzle and kept wet until the concrete has hardened sufficiently to walk on without injury, then the burlap is removed and the concrete covered with straw and sprinkled again or in some instances dykes are built and the pavements flooded with water. Great care should be used to make sure the pavement is kept wet by sprinkling and some moisture retained for two weeks and more especially the first three or four days because it is in the early stages that the most damage can be done if curing is improperly carried out.

Opening Pavement to Traffic.—Our specifications in the past have required traffic to be kept off the pavement for 30 days or longer if considered necessary; however, we have in the summer months considered 21 days sufficient and have opened most all pavement within that period. In some urgent cases pavement has been opened to traffic in 14 days. In our recent supplemental specifications the date of opening the pavement is left entirely to the engineer. It is our intention to make test beams at intervals from the concrete as it comes from the mixer and as deposited on the road. These test beams are to be treated and cured the same as the pavement slab. The beams will be broken at various intervals with a portable testing machine and the pavement opened to traffic when the test beams show what we believe to be a sufficient strength, but of course not until the curing period has expired and the pavement cleared ready for traffic. It is believed that during the summer months most of our concrete pavements will be opened to traffic within about 18 days.



Use of 10 ft. Float in Smoothing Pavement and Method of Covering with Burlap

Acknowledgment. — The foregoing paper was presented at the 14th Annual Purdue Road School, Lafayette, Ind., Jan. 16-20.

Highway Policies in California

The State Department of Public Works of California will spend over $50,000,000 during the present biennium on its highways. The outstanding phases of the present highway policies are summarized as follows by B. B. Meek, director of the department, in April California Highways and Public Works, the official journal of the State Department of Public Works:

1. The present highway system must be completed within as short a time as is compatible with sound engineering and economical construction. We want haste, but not the kind of haste that makes waste.

2. The inclusion of new roads into the state system should be postponed until such time as the present system nears completion.

3. Adequate provision for future development should be assured both through providing wider rights of way now, and through reserving for public use areas adjacent to the highways of particular scenic charm or recreational value.

4. On roads where present traffic is not heavy, a low cost surface should be provided that will adequately care for the existing travel, and which will become a part of a well-packed base, when future traffic demands a larger pavement investment. Our recommendation for this class of highway is the oil and rock surface, known as the California type pavement.

5. Relocation of roads should be made where it is possible to eliminate grade crossings by such realignment. An agreement should be reached between state highway and railroad officials for a definite cost-sharing policy in the construction of grade elimination and grade separations.

6. Repair on our highways must be immediate and continuous. Every maintenance man in our work must also be a minute man. Regular traffic counts and studies must be made to determine traffic trends and to enable present roads to be widened and thickened in advance of deterioration or destruction.

7. The routing of present unlocated roads by "the most direct practical route" as prescribed by law and as determined by experts, trained and skilled in this work, must govern in all location matters. In the words of Governor Young, location of our highways must be determined "by traffic pressure rather than by political pressure."

8. Highway funds are to be budgeted for each biennium in advance of their expenditure. Suggestions and proposals for highway financing outside of and in addition to present revenues should be discouraged. Our present income we hope will be adequate and if we spent it wisely we believe will be continuous.

9. Construction of toll roads for through traffic should be discouraged. This is the business of the state and counties.

10. Construction should be by contract rather than by day labor, unless the bids of contractors are unreasonable.

$10,000,000 Boulevard for Montreal, Que.—The city of Montreal, Quebec, is considering the construction of a $10,000,000 boulevard. According to plans prepared by Chief City Engineer H. A. Terreault, City Hall, Montreal, the highway will be 150 ft. wide and will extend from St. Anne de Bellevue to Bout de l'Ile. The proposed highway will be paid for on a property valuation basis by the municipalities served.

Bituminous Treatment of Gravel Roads and Earth Subgrades

Paper Presented at 14th Annual Michigan Conference on Highway Engineering

By F. C. LANG

Associate Professor, Highway Engineering, University of Minnesota; Engineer of Tests and Inspection, Minnesota Highway Department

THE application of bituminous materials to the surface of earth and gravel roads is not a new idea. Tar and oil were used on roads when automobiles were built to resemble buggies, even to the extent of being provided with whip sockets. However, after a few years, interest in this type declined, due, I think, to an inadequate maintenance organization, and the fact that the large increase in the number of motor vehicles made the pavement of main roads necessary. About 1924 there began a revival of interest in the development of surface treatments.

There is at present a considerable variation in the methods of applying bituminous material in surface treatments and the kind of bituminous material to use. I consider that the term includes all treatments where the bituminous material is sprayed over the road surface, whether it depends on a penetration into an existing road surface, or the mixing of the bituminous material and the material on the road by means of blades or drags or a combination of the two. Rarely is the bituminous surface treatment over 2 in. thick unless it has been applied over a number of years and gets deeper by scarifying and re-mixing. Any hauling of a pre-mixed material onto a road would not be included as a surface treatment, and by title this paper does not include treatments of broken stone roads or earth roads unless the treated earth road is considered as a subgrade for some type of surfacing.

Why Methods Vary.—A considerable variation in methods of applying bituminous material on gravel roads is to be expected for two reasons. First, bituminous surface treatments are now in the experimental or developing stage. Second, there is a considerable variation in the types of gravel roads in various sections, and also in subsoils, drainage, climate, and traffic requirements. Any natural soil road which has been covered with gravel is ordinarily considered a gravel road, yet there is a vast difference in construction methods and materials used. Some gravel roads have been constructed in two or more courses in the so-called trench method, using large stone, especially in base course, with a small amount of fines, and about 10 in. total thickness, quite similar, in fact, to the old water-bound macadam construction. As a contrast to this we have the feather-edge method used in Minnesota: gravel with 1 in. maximum size and with a large percentage of fines, up to 60 per cent passing a 10-mesh sieve, is placed on a prepared, flat subgrade and compacted under traffic. The total thickness at center is rarely over 6 in. and approaches zero thickness near shoulder line. The amount of clay binder also varies. A gravel surfaced road is primarily a cheap road and local material must be used without too much cost in its preparation. The type of bituminous material to use largely depends on the non-bituminous materials in the road surface.

Why Bituminous Surface Treatments Are Popular.—At present bituminous surface treatments are becoming very popular for the following reasons:

(1) Eliminate dust. This adds to the comfort of the motorist as well as the resident along the highway, especially in municipalities, and also adds to safety.

(2) Conserve material. Estimates place the amount of material lost from an untreated gravel surface road at about 1 in. to 1½ in. per year, depending, of course, on the amount of traffic. This would mean about 400 cu. yd. per mile per year, the value of which, in turn, depends on the cost of gravel and ranges probably from $400 to $1,500 per year.

The conservation of the gravel in a territory is greatly affected. In many localities the supply of gravel is rapidly being depleted. This means that not only will we have long hauls to the road, which will mean more expensive gravel, but that none will be left for township and secondary roads where the gravel for surfacing would have lasted a long time. This is very important, as a good system of secondary and township roads is essential in a complete highway system.

(3) Lower maintenance and vehicle operating costs. This, in turn, depends on the amount of traffic. Statistics compiled in Minnesota show that the maximum economical limit for gravel roads is about 600 cars per day, while our bituminous treated roads are carrying up to 1,500 vehicles per day without any signs of distress. The saving to vehicle operation can be computed from some of the figures compiled by Professor Agg. We consider that a properly maintained bituminous surface road should have very little, if any, more resistance to traffic translation than asphaltic concrete. On this basis the saving for 1,500 ton miles per day would be about $17, or $5,100 for a 300-day year.

(4) Better riding surface. Our experience has shown that the maintenance department is able to maintain a smooth riding surface on bituminous surface treated roads practically throughout the year. The untreated gravel road gets sloppy after rains and during a dry period it seems to be practically impossible to entirely eliminate chatter bumps and rhythmic corrugations or washboards.

(5) Gradually build up a surface crust which if on permanently graded roads will provide better foundations for pavements.

I shall not attempt to give the details of construction used in various states. Numerous papers have been published during the year describing these in detail. Among the states most active in the present development of bituminous treatments are Oregon, California, Nevada, North and South Carolina, Wisconsin, Michigan, Illinois, Indiana, Ohio, and Minnesota. While a study of the methods used in the various states is essential, we must keep in mind that bituminous treatment, for the reasons already given, is a local problem. Not only do the conditions in one state vary from those in another, but there are also big variations within one large state.

Conditions in Minnesota.—I shall now describe conditions as we have them in Minnesota and the methods used. Our bituminous surface treated roads may, in general, be divided into three classes:

(1) Those sections where the subsoil is a sand and the gravel surfacing is deficient in binder, as usually occurs in sandy areas. The more ¼ and ¾-in. stone in the gravel surface the better the results.

(2) Compacted clay and gumbo subgrades which have been treated prior to a light application of gravel. The roads treated have either been located in sections where gravel surfacing had to be shipped in and is very expensive, or on certain gumbo subgrades which appear to eat up the gravel during wet periods. Minnesota does heavy grad-

ing in these sections, running 14,000 to 20,000 yd. per mile for a 30-ft. road. This brings the surface of the road from 4 to 5 ft. above the bottom of the ditch line and the ditches are usually quite wide. I do not believe our treatment of this class of roads would be successful if it were not for the high grade line which adds to the stability of the roadbed.

(3) The treatment of gravel surface roads on clay and loamy subgrades.

Treatment on Sandy Subsoil.—I will now discuss each class in more detail:

A typical analysis of the subgrade in the sandy area is as follows:

	Per Cent
Retained on 10-mesh sieve	0.5

An analysis of part passing No. 10 is as follows:

	Per Cent
Total sand	90.2
Total silt	5.5
Total clay	4.3
Cementing value	2.0

A typical analysis of the resurfacing used on this type is as follows:

	Per Cent
Passing 1 in. retained on No. 10	65.0

An analysis of part passing No. 10 is as follows:

	Per Cent
Total sand	95.0
Total silt	3.1
Total clay	1.9

Of course there are variations from this typical analysis. We have used both tar and asphaltic cut-back oils for these conditions. The number of miles of tar is 120.3. The number of miles of asphaltic cut-back oil is 1. We have been well satisfied with our tar treatments. The asphaltic cut-back oil is really an experimental piece. A typical analysis of the tar used is as follows:

Water	.....
Specific viscosity (Engler 50 cc. at 40° C.)	11.7
Total bitumen	97.41
Distillation—	
0—170° C.	1.4
0—270° C.	22.8
0—300° C.	29.9
Softening point	44.2

A typical analysis of the asphaltic cut-back oil used on the one-mile experimental piece is as follows:

Specific gravity	.948
Flash	76° C.
Specific viscosity at 60° C.	11.2
100 penetration residue	60.4
Ductility of residue	58
Loss at 163° C.	13.0
Total bitumen (soluble in CS_2)	99.94
Total bitumen insoluble in 86° Naphtha	17.43

The method of application is as follows:

The first operation consists of grading all of the loose material to the center of the road, thus forming a smooth hard surface. In only a few instances have we resorted to sweeping. The ideal road surface at the time of the first application should be smooth, well compacted, dry, and free from dust.

The second operation is the spraying of the prepared surface with about ¼ to ⅓ gal. of tar heated to about 130° F.

Third operation. After about 24 hours, or when the first application has completely penetrated and set up, the surface is again sprayed with ¼ to ⅓ gal. of tar, and at once covered by blading the loose material previously removed on to the fresh tar. In case the bladed material contains an excess of fines of a non-granular nature, it is wasted over the shoulder, and suitable material for covering is windrowed on the opposite shoulder, bringing the total amount of covering material up to about 350 cu. yd. per mile. The best covering material is pea gravel (retained No. 10 passing ⅜ in. screen), and where gravel plants are near this is used; usually, however, selected local deposits have been used.

Fourth operation. The opposite side of the roadway is then cleared with a grader, throwing the loose gravel into a windrow over the edge of the tar section and leaving the opposite side free for treating.

Fifth operation. The remaining side is treated with penetration coat and allowed to set up the same as the first side treated.

Sixth operation. This side is then treated with second coat of tar and loose graded material bladed in from side for cover the same as before.

Seventh operation. The roadway is dragged a number of times to smooth it and work all the gravel possible into the tar. This dragging operation is continued for a period of three to five days or until the surface has set up to such an extent that dragging does not do any good, or the surface at that time is in a hard condition. At this time any small breaks or holes should be immediately patched with pre-mixed material, using the same grade of tar and the same material as is used for the cover coat. If large holes develop, a coarser grade of road metal may be used to insure a more stable patch. At completion, the crown for a 30 ft. top would be from 6 to 9 in. This method is really a combination of the penetration and surface mixing methods. Its success depends largely on penetration into compacted surface. We find this makes a good bond between old road bed and surface, and we have had very little trouble with creeping of surface.

On this type of road the daily traffic varies between 700 and 1,500 vehicles per day. Initial cost for 24 ft. surface ranges between $1,600 and $1,800 per mile. The cost of maintenance varies between $300 and $600 per mile per year. One patrolman with occasional auxiliary equipment can successfully handle 20 miles of this kind of road, taking care of the patching, cutting of grass, repairing washouts, etc.

Treatment on Compacted Clay and Gumbo Subgrades.—Of the second class, treated subgrades, we have 131 miles. The subgrades treated have been in the extreme southeastern and northwestern parts of the state. A typical analysis of the subgrade in southeastern Minnesota is as follows:

Passing No. 10 sieve	99.8%
Total sand	1.5%
Total silt	56.8%
Total clay	41.7%
Cementing value	135

A typical analysis of the gumbo soil in northwestern Minnesota is as follows:

Passing No. 10 sieve	99.5%
Total sand	8.6%
Total silt	21.8%
Total clay	69.6%

In all of our subgrade treatments we have used a straight distillation midcontinent residuum. A typical analysis of the oil most used is as follows:

Specific gravity	1.044
Flash	164° C.
Specific viscosity at 60° C.	12.9
100 penetration residue	65.2
Ductility of residue	100+
Loss at 163° C.	2.8
Total bitumen (soluble in CS_2)	99.91
Total bitumen insoluble in 86° naphtha	16.23

The method of treatment is quite similar to the method just described for tar treatment. Considerable care is taken to see that the subgrade at the time of treatment is well compacted, smooth, free from dust, and dry. Weather conditions play a great part in the application of oil on this class of work. Warm weather aids the penetration of the oil into the subgrade, and rainy weather tends to slow up the work because it is hard to get the surface dried out sufficiently to allow a penetration into the grade far enough to get the depth desired.

About 400 cu. yd. of cover material per mile is used. The cover material as previously described is preferably pea gravel, but usually selected local deposits are used. The gravel takes the wear. Too much emphasis cannot be placed on having the surface of the road well above the water table.

Treatment of Gravel Surface on Clay and Loamy Subgrades.—In the third class of treatments, the gravel surface on clay and loamy subgrades, I am unable to give any typical analysis of the subsoil or gravel surfacing. Included in this class are the intermediate soils between sand and clay. The surfacing also varies, but, in general, where we have clay subgrades there is considerable clay binder in the gravel surfacing; however, it is not uniformly distributed. Belonging to this class of roads we have 21 miles of tar, 17 miles of asphaltic cut-back oil, and 96 miles of midcontinent residuum. The choice of bituminous material to use is made after an examination and analysis of the composition of the gravel surfacing and the subgrade, also taking into consideration the thickness of the compacted gravel surface. I am unable to give any definite figures on which the decision as to the class of bituminous material to use is finally made. In general, tar and asphaltic cut-back oils have been the most satisfactory on granular soils, and the straight run residuum on the heavy soils. The method of application is entirely similar to the method previously described for tar treatment on granular soils.

Keeping the Road in Service.—When necessary to use the road during time of construction, we endeavor to protect the motorist from temporary inconvenience in the following ways:

(1) We keep one-half of the road in

such condition that traffic can go over it without getting into the freshly placed material.

(2) We place warning signs at the ends and along the section being treated, informing the motorist what to do.

(3) Patrolmen are placed at the ends to stop the motorist and tell him how to proceed.

At the same time we expect the cooperation of the public and there have been times when it has been necessary to have police power bestowed on patrolmen to enforce requirements, that is, in driving with unnecessary speed on freshly laid material.

Bituminous surface treatments must not be considered in the same category as hard surface pavements. At the present time it appears to be the best solution for that large mileage of intermediate roads where the untreated road is not satisfactory and the traffic is not sufficient, or money not available for pavement. At present this type of surface is extremely popular with the traveling public. In Minnesota the maintenance and construction of all primary highways, including routes through cities, is entirely under the jurisdiction of the Highway Department. Further than that we have one specially trained man who is put in immediate charge of bituminous treatments. No roads are treated without a special examination of local conditions. During construction we place inspectors in charge of the various projects, who work directly under one head. It is also the duty of the man in charge of this type of treatment to follow up the maintenance and see that the local officials in charge take care of the road.

We consider that many bituminous treatments are still in the developing and experimental stage. We always try out new material, which we think might be satisfactory, on a small scale. New methods are being developed. Regardless of purchase price, we do not buy any large amount of new bituminous material until experience has shown that it is satisfactory.

Nevertheless, I am not entirely satisfied. Our field work has proceeded faster than our laboratory research although this has not been entirely neglected. We should develop some laboratory method for ascertaining what particular bituminous material would be most satisfactory on the particular soil to be treated. Field results show a considerable variation in the properties of road oils complying with one specification. It is difficult to find a man with adequate training and sufficient enthusiasm to successfully carry on research work of this character, especially for the salary that there is usually available. Much money will be wasted throughout the United States during the next few years because basic principles and test have not been established.

Margerum Asphaltic Limestone

Development of the Alabama asphaltic limestone deposits which started six years ago at Margerum, Ala., is stated to have proved up with diamoned drills huge tonnage of bituminous limestone, comparing most favorably in quality with the world famous European deposits. Margerum asphaltic limestone pavements laid in numerous Southern cities and state highways also are said to have given uniformly excellent results.

Mineralogically, the deposit at Margerum is a limestone impregnated with bitumen. It occurs in a strata from 7 to 18 ft. thick covered with 3 to 20 ft. of overburden. The bitumen content varies from 3 to 8 per cent. The rock is sorted in the quarries, then mixed there and in the plant so that it is claimed the pulverized asphaltic limestone will contain uniformly from 5 to 6 per cent of bitumen.

The production of Margerum asphaltic limestone is a fairly simple process. The rock is stripped and blasted to crusher size. It is hauled over a standard gauge railroad to the crushing plant where it is reduced in the primary crusher to about 4 in. maximum size. The rock is then carried to hammer mill type pulverizers which further reduce it to a size that will pass a ⅜ in. sieve —the size at which it is laid in a pavement. From the pulverizers, Margerum asphaltic limestone goes to large storage bins, ready for shipment.

Variations in the bitumen content of Margerum asphaltic limestone is not a source of trouble. Though the amount of bitumen added at the paving plant can readily be increased or decreased, still careful attention is given during production to control, within close limits, of the bitumen content. This control starts with the testing of samples from closely blocked core drilling. The plant laboratory also tests samples taken daily from the working faces of the quarries. The rock is sorted and mixed in the quarries and is further mixed during the various steps of crushing and pulverizing. This insures a uniform product, especially after the additional mixing incident to loading and unloading the cars. However, additional precautions are taken at Margerum to insure uniformity by using a storage bin that holds at least one day's production. The pulverized Margerum asphaltic limestone is distributed back and forth over the length of the storage bin by a belt conveyor equipped with a travelling tripper. The asphaltic limestone is loaded into railroad cars through numerous traps in the bottom of the bin. Systematic tests are made each day on the plant production and each car is sampled and tested after it is loaded. A notice is sent out with each car showing its bitumen content.

Margerum asphaltic limestone, as shipped ready to be mixed and laid, has the appearance of finely ground dark colored limestone screenings. At the mixing plant there is added sufficient asphalt cement of the proper penetration for climatic and traffic conditions and the material is spread, rolled and opened to traffic. The operation at the mixing plant is simple.

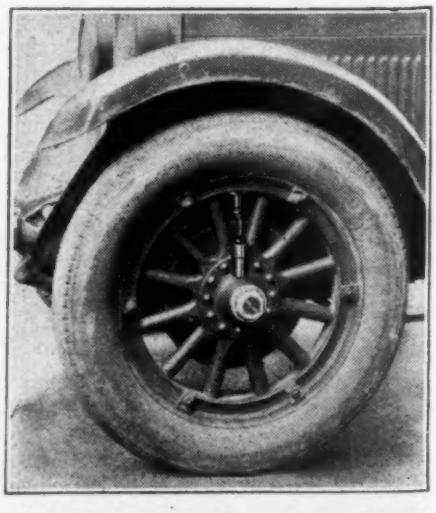
It is stated that Margerum asphaltic limestone may be laid on any type of new foundation that would be satisfactory for sheet asphalt or asphaltic concrete. It is also claimed to be especially adaptable to resurfacing old concrete, stone, block, bituminous macadam, waterbound macadam, or gravel surface.

The Alabama Rock Asphalt, Inc., Birmingham, Ala., handles the production of Margerum asphaltic limestone.

Yellow Jack-It Automatic Tire Inflators

Proper inflation is highly important to satisfactory service from balloon tires. A new device, the Yellow Jack-It Automatic Tire Inflators, insure this proper inflation at all times, and without as much as a thought from the driver, according to claims made by the manufacturer. This device, shown installed, is fully automatic and keeps the tires inflated to a predetermined pressure. If they have lost air by any reason, a few miles of driving brings them back to normal pressure, thus preventing rim cuts and broken side walls from driving with under-inflated tires, say the manufacturers.

The valves are set to deliver the proper amount of air and when up to pressure, no more air will enter the tire, as the valve is so set that surplus air passes out through the exhaust. The makers, Yellow Jack-It Mfg. Co., 225 North Green St., Chicago, Ill., claim these tire inflators increase tire mileage 25 to 50 per cent. A post card will bring the full details.



This Automatic Tire Inflator, Shown Installed, Keeps Balloon Tires Inflated to Desired Point

Handling Landslides Along Highways By Hydraulic Sluicing

Methods and Costs of Work Being Done in California

HYDRAULIC sluicing is being used very successfully in Humboldt County, California, by T. A. Bedford, District Engineer, California State Division of Highways, for removing slides from highways and in controlling slide areas.

In one instance a slide so completely covered a portion of the state highway that in many places not even an appearance of the highway was left. This slide area was ⅛ mile long, ¼ mile wide and 400 ft. high. The material was disintegrating blue shale, marked with many cracks and fissures. It is estimated there will be 200,000 cu. yd. of this material to move in the next few years. For handling this slide area a 4-in. pipe line was brought from a creek with a 200-ft. fall, and ½ mile distant from the slide. Two deep trenches were sluiced into the mountain side, and so arranged that they converged into a sluiceway. These trenches catch the slide as it comes down the mountain side and carry the material into the sluiceway, a 6x5-ft. box with a lip on the upper end. The trenches also drain the water out of the slide.

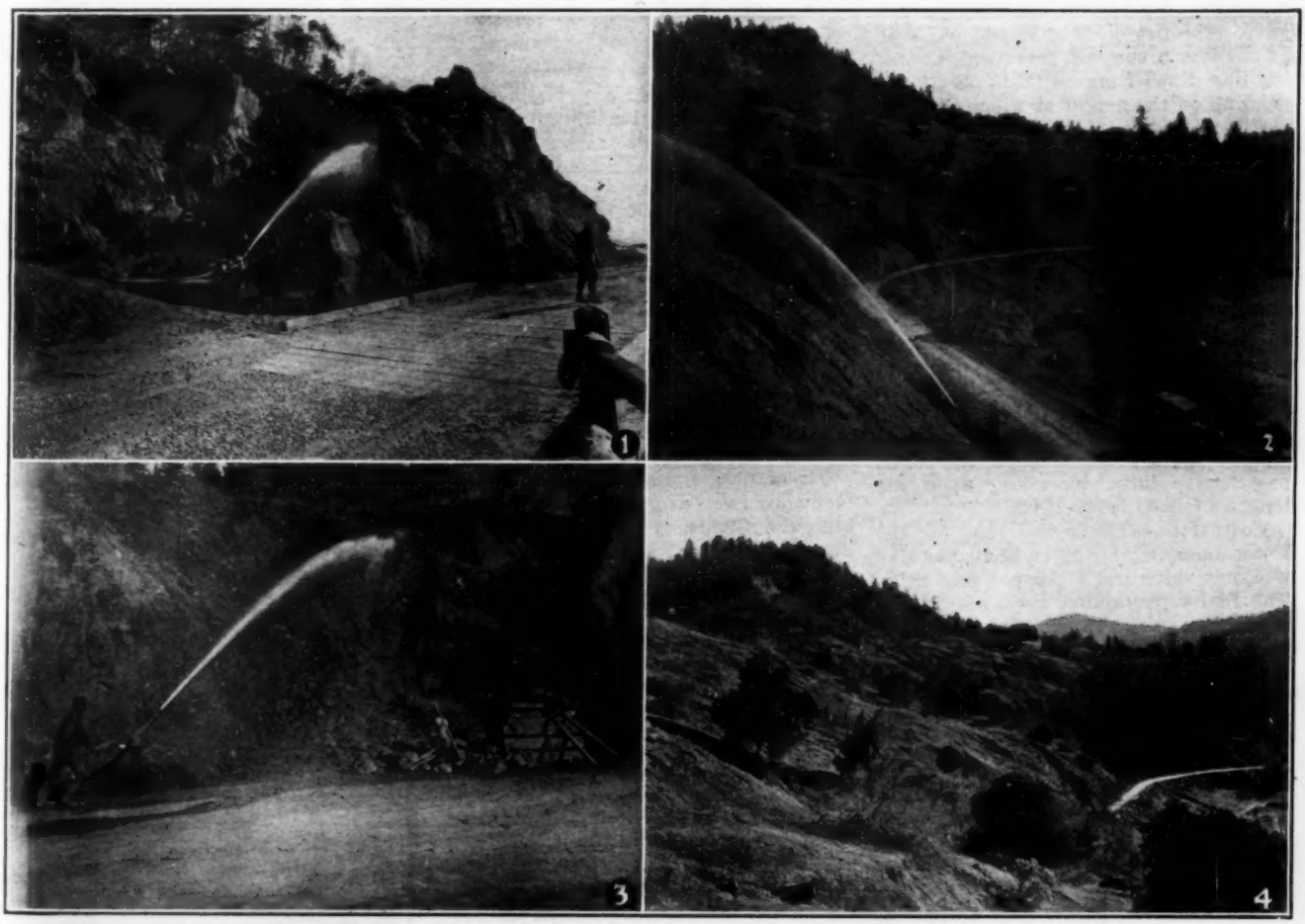
The sluiceway was on a 1 to 4 slope, but Mr. Bedford recommends a 1 to 3 slope, so that the slide will automatically dispose of itself without sluicing.

In the operations at the slide mentioned above two men were employed rolling the bigger stones into a sump which would hold several yards of material. The rush of water and mud carried these big rocks through. Three men moved 300 cu. yd. of material a day at a total cost of 10 ct. per cu. yd., distributed as follows:

	Ct. per Cu. yd.
Wages	4
Transportation	1
Sluiceways	2
Installation	1
Supervision	1
Delays	1

Mr. Bedford states that when the sluices are dug and the slides trained to follow them, very little care is necessary. Last winter 25,000 cu. yd. of material went through one of the sluiceways, requiring very little attention.

Mr. Bedford has furnished us with the following details of a sluicing job that he is now carrying out. This work covers excavating high, compacted sand bluffs and sluicing the material into the ocean. The water is obtained from



Hydraulic Sluicing Operations in Humboldt County, California, for Controlling Land Slides Adjacent to Highways
(1) Hydraulic Method Being Used for Removal of Sand Bluffs 200 ft. High Overhanging Highway Near Trinidad, Calif. (2) Monitor Hydraulicking Trenches, Two of Which May Be Seen About the Center of the Picture, Converging onto the Highway and Passing Under It Through a Big Box. (3) Monitor Putting a Slide Through the Sluiceway with the Assistance of Two Men Working in the Sump Rolling Boulders in Place. (4) General View of about 300 Acres Disintegrating Shale, Blue Mud and Boulders, about 500,000 Cu. Yd. of Unstable Material Slowly Moving Down onto the Highway

Highway Almost Completely Covered by a Slide Following a Severe Storm

a nearby creek and is raised by a booster pumping outfit consisting of a 5-in. Byron-Jackson single stage centrifugal pump direct connected to a 50 hp. Cadillac gas engine. This pump lifts the water to an elevation of 94 ft. to a second pump—a 5-in. Dean-Hill 6-stage centrifugal pump directer connected to a 145 hp. Sterling gas engine. The lift on this second outfit is 22 ft., over a summit, from which point the line drops from 25 ft. to 55 ft., depending on the height at which the nozzle is working.

The pipe line between the pump at the source and the 6-stage pump consists of 100 ft. of 5-in. pipe and 500 ft. of 4-in. pipe. The pipe line between the 6-stage pump and the nozzle consists of 1,100 ft. of 4-in. pipe and 200 to 400 ft. of 3-in. pipe. On the end of the pipe 2½-in. fire hose is used. The length of hose varies from 50 to 300 ft. The nozzle is an ordinary 1¼-in. fire nozzle.

The quantity of water delivered varied from 280 to 350 gal. per minute, with a nozle pressure of 30 to 50 lb. per square inch, depending upon the length of hose being used.

Cost Data.—The rental rate for the lower pumping outfit is $4.40 per day working shift and $1.10 per idle shift. The fuel consumption averages 36 gal. of gas per shift. In addition 5 qt. of oil was used per shift.

The rental for the upper pumping outfit is $8 per working shift and $2 per idle shift. The gas consumption averages 53 gal. per shift; 10 qt. of oil per shift are used. The original installation cost was approximately $600. This does not include the cost of pumps, engine and pipe.

The operating crew consists of a man on each pump at $5 per day and a nozzle man at $5, with a helper at $4.50 per day. Part of the time of the maintenance foreman and superintendent, as well as a portion of the maintenance overhead was charged to the job and amounted to approximately 10 per cent of the labor charge or $2 per day. The outfit operated on an 8-hour shift per day. The operating cost per day was as follows:

	Per Day
Labor	$19.50
Equipment rental	12.40
Fuel and oil	20.00
Overehad and supervision	2.00
Total	$53.90

The yardage moved has varied from 350 to 700 cu. yd. per day, the average being such as to give a unit cost of 10 ct. per cubic yard.

Indiana Truck Announces New Models

Two new 3-ton road builders have been added to the line of the Indiana Truck Corporation, Marion, Indiana. Announced for the first time at the recent good roads show in Cleveland, these models, 127A and 627A, 4 and 6-cylinder engines, respectively, are now in production at the Indiana plant.

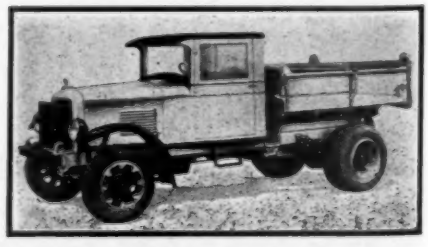
These new Indiana models are designed as two 7-bag batch road builders, and are furnished with a 72 cu. ft. dump body, which is the right capacity for two 7-bag batches, 1:2:3 mix; two 6-bag batches, 1:2:4 mix; or two 6-bag batches, 1:2:3½ mix, when the cement is carried in sacks on top of the sand and stone.

The patented "Tors-Elim" three-point suspension mounting of motor and radiator units (exclusive to Indiana Trucks) is used on these two models of Indiana Road Builders. When cab is specified (extra equipment), it will come with the "Tors-Elim" three-point suspension mounting. This new cab carries the same lines and appointments as the present Indiana DeLuxe Cab, but is somewhat roomier and is built with an all-metal roof.

Indiana "Tors-Elim" three-point suspension mounting provides a suitable support for the radiator, hood, cowl and cam with respect to the frame. It frees the radiator, hood, cowl and cab from any torsional strain and vibration, to which the chassis is always subjected. This prolongs the life of the cab and adds to easy riding qualities. This three-point suspension mounting maintains and keeps the radiator, hood, cowl and cab from being affected in any way, regardless of the torsional strain imposed upon the chassis, and these units maintains their position substantially as a single unit independently of the chassis, according to the manufacturer.

This new mounting eliminates the constant punishment ordinarily received by the radiator, due to the constant twisting of the chassis. One of the most important advantages gained with this new radiator mounting is the improvement in the steering at high speeds. By severing the rigid relation of the radiator to the front axle assembly, the synchronizing of the radiator and hood with the vibration or tramp of the front axle assembly at high speeds over uneven or rough roads has been eliminated. With the new hood mounting in the three-point suspension there is no movement of the hood in relation to the cam or radiator, preventing hood squeaks, wearing out of hood lacing, and marring finish on cowl of cab and radiator. The gasoline tank is under the seat of the cab, also on a three-point mounting, freeing it from the extreme twists of the frame.

Model 127-A Indiana Road Builder is powered with a 4-cylinder engine, 4¼ by 5¾ in., with a piston displacement of 326.3 cu. in.—Model 627-A, with a 6-cylinder engine, 3¾ by 5 in., piston displacement of 331 cu. in., developing 67 h.p. at 2,000 r.p.m. The transmission is the latest type 5-speed unit power plant, selective sliding gear design, five speeds forward, two in reverse. A speed of 25 miles per hour may be obtained indirect with the 127-A model, and 30 miles per hour in the over-drive, while the Model 627-A is capable of 30 miles per hour in direct and 35 miles per hour in the over-drive. Tires are pneumatic cord, 32x6 in. front and 34x7 in. dual rear. The steering gear is of the cam and lever type, providing remarkable easy steering. The frame is of heat treated pressed steel construction with a breaking strength of 90,000 pounds to the square inch.



New Model of Indiana Road Builder Recently Announced

Duties of the Division Materials Engineer in Wisconsin

Paper Presented at 17th Annual Wisconsin Road School

By M. W. MELCHER
Assistant Engineer, Wisconsin Highway Commission

I SHALL endeavor to discuss this subject from the standpoint of my own experiences in Division 8, and while each division has its own problems concerning materials, the general idea will, I believe, be applicable throughout the state. Obviously the work falls into two phases: duties in the field and duties in the office, but before either are explained let me say a word regarding what might be termed prerequisite activities.

Anyone connected with the game of highway materials should have a fair knowledge of the construction and the maintenance work which is going on about him. Without question the best training in this respect cannot be gained from casual observation, but from actual work in the field as a resident engineer, and actual work on plans in the office. This affords opportunities to study the effect of various materials in different phases of construction and to acquire a knowledge of the problems which confront various contractors, and which problems naturally are reflected in their bids on similar work in the future. I can frankly state that the four years I spent on construction work in Division No. 8 taught me things which I may possibly have learned through the experience of others, but never in as thorough a manner.

Quite naturally a knowledge of the specifications is essential, for it not only saves you an embarrassing situation when asked concerning them in general but it also places you in a position to regard or disregard at sight materials concerning which you may be questioned. While a highly technical knowledge of geology is not necessary, I consider a knowledge of general and glacial geology essential to any division materials engineer, and this knowledge cannot be gained through books alone, but involves considerable actual work in the field. This leads up to just one important phase of the work—familiarity with the territory in which you work. You should know the approximate depth and nature of bed rock. You should know the character of the overlying drift, if any—whether or not it is apt to be rich or poor in road materials, and what geologic features are apt to be the most common. You should be thoroughly familiar with the soil conditions. A knowledge of these facts often enables you to give a fairly intelligent answer to questions which may be asked you in the office concerning this or that particular area.

Field Duties.—During the summer of each year a number of road material parties are sent out from the main office to locate surfacing material and concrete aggregate for the various contemplated construction jobs. The materials engineer outlines the program of work for the party or parties assigned to his division, and even though these parties are under the direct supervision of the state geologist, it is up to the division materials engineer to offer any advice or suggestions which may aid the party in their work. This he should be able to do, as he is in a position to know the area under survey, and also just what is desired in the line of materials. After their survey is completed he should look over the deposits they have found, in order to familiarize himself with their exact location, thereby saving himself or the test pitting party later on considerable time. In the case that the materials engineer has little or no knowledge of geology, the time he spends with a road material party will be to his advantage inasmuch as he can in the source of a summer gain a fair knowledge of glacial geology. On the other hand, he can impart to the road material party engineering information which will help them in their future work.

Work of Road Material Parties.—Let me say a word or two here in connection with the work of these road material parties. Merely because their chief object is to locate material do not assume that they can always find it just where we would like to have it, nor in the quantity or quality which we would always like to have it. Should they report no material, do not blame them for a situation which no one can help, nor consider their services a total loss, but bear in mind that it is equally important for us to know we have nothing as it is to know that we are fairly well supplied, as either case gives us a basis for future figures. Remember that one real strike on a long project may mean a saving of more than the expenses of all the parties in the field.

In a large number of cases pits which supplied the original construction job with gravel, have supplied the counties with maintenance material. Quite often, however, the counties find it necessary to locate new gravel deposits for their gang maintenance jobs, and in a number of cases we have been called upon to help locate material for this work, lack of time not permitting a regular material investigation. In a number of instances deposits suitable for maintenance work have been located, which have saved the counties considerable money.

Test Pitting.—Test pitting should follow the material investigation as closely as possible. The road material parties, with the cooperation of the materials engineer, recommend certain deposits for first consideration. Should these locations, which are consequently test pitted first, prove unsatisfactory, it is necessary to continue the test pitting to other locations until such deposit or deposits as the project demands are found. Owing to the absence of paving work in Division No. 8, this work concerns only the gravel for road surfacing purposes, in consequence of which we have not had occasion for test pitting beyond a depth of 10 or 11 ft., the limit, I believe, without the use of cribbing. I might add here that the greater percentage of our gravel deposits in Division No. 8 are shallow as compared with those in the southern part of the state. Outwash, with the exception of a few deposits along the Chippewa, Flambeau and St. Croix Rivers, rarely exceeds a depth of 8 to 10 ft. (80 per cent of the old beaches we have disclose a gravel face of less than 7 ft.). Terminal moraine features, including kames, are an uncertainty, and oftentimes require holes every 25 ft. to guard against probable sand pockets. In this connection let me add that the materials engineer should be so qualified to tell at a glance about how many test holes will be needed to determine the character of a formation and just when they will be needed. For example, holes in an outwash flat may be 100 to 150 ft. apart and still tell the story. Surface indications and contour almost always disclose the content of an esker, in which formation a 100 ft. hole is representative of the entire face, which may be 20 to 30 ft.

Labor for Test Pitting.—So far as test pitting labor is concerned, I will admit that the ideal situation would be a crew supplied with a small truck and equipped with all necessary tools, who could follow up the road material parties. This would, of course, mean their

employment from July until September or October. In Division No. 8, however, the actual amount of necessary test pitting has never, to my knowledge, warranted such outlay and expense. Consequently, we have up to the last year hired local labor to do this work. In most cases they were farmers who needed the $3.00 or $3.50 per day, and the feeling left in that particular locality was considerably better than if we had imported labor. This procedure, however, had two bad features—First: Local labor was in some cases hard to find, thereby causing considerable delay. Second: In some cases it gave the local people a good insight into the material situation in that area, which later affected the price of gravel to a marked degree. In consequence of this, during the past season I carried two men with me during the months of October and November who did most of the test pitting for the 1928 season. In some instances it was necessary to hire additional labor, and while it is true that these men did not do actual test pitting for 10 hours each day in the week, there was always the satisfaction of knowing that they were available when wanted. The data gathered from the test pitting operations include the exact location of the deposit, with reference to section lines or other established point, owner, records of the test holes, enough screen analysis so that the average will be representative of the entire deposit, the exact dead haul to the project and the nature of this dead haul. Inasmuch as we now have a number of the material investigations for 1929 made, we will in addition to the remainder of these have the 1930 investigations well under way, if not completed, by the end of next summer. This will enable us to do considerable test pitting for 1930 next year, thereby giving us an opportunity to know the exact material situation two years before the construction starts.

Purchasing or Leasing the Deposit.—After a satisfactory deposit has been located and thoroughly test pitted, it should be bargained for as soon as possible. This is at times quite easy to do. At other times it presents a problem which requires both time and patience, for there are property owners who want exorbitant prices for their land, when they realize that either the state or county desires it, others who do not care to sell any fraction of their land, but will dispose of the forty, and others who do not care to sell at all.

Without question the most advantageous deal for us is a deed to the desired parcel. However, there are a few owners who do not care to sell outright, in some cases their titles not being clear, in others merely the fact that they do not care to have the records changed. In such cases the next best deal is a lease, and should the quantity of desirable material be large, the term should be long enough to enable the county to completely exhaust the deposit before the lease expires. I would say that a 15 or 20 year lease is almost as good as a deed. Where a deposit shows signs of being exhausted with the completion of the project, a short term lease is of course equally as good as one of longer term. In some cases owners have sold only under threat of condemnation proceedings. Purchasing gravel on a yardage basis is resorted to only in excess cases in Division No. 8, sometimes where the owner has previously disposed of gravel in that manner, others where the deposit is so small that it makes little difference.

I consider it poor policy in the case of larger deposits, for the reason that in the course of years the amount expended will amount to thousands of dollars. In addition, take a case where material for a project has been purchased on a yardage basis, and after a few years we wish to resuface the job, or possibly the one adjacent. The owner may feel that he has a monopoly on material inasmuch as his pit has already been opened and the quality of material is known, and in consequence he may raise the price. In a case where he actually is in possession of the best deposits we would be forced to pay the additional cost, a situation which could have been avoided had the land been bought or leased in the first place. When funds are not available for the project the deposits should be optioned to secure for a year during which time funds may become available; or the counties may be induced to advance the money.

Advice to Contractor.—When surfacing operations are begun the materials engineer is able, in a great number of cases, to give the contractor considerable advice regarding his plant, set-up and methods of operation and removal, not so much perhaps with the idea of saving him money, but with the idea of speeding up the job and guarding against what might have been an unnecessary delay. After the plant is in operation he should make occasional trips over the job. He is in the best position to know what the pit can produce, and what the resultant product should be. Screen analyses of the product coming from different pits must compare favorably with the screen analyses which were taken before the pit was opened. In a number of cases we have found it necessary to make slight changes in the operation methods in order to get what was wanted.

Among the other field duties of the materials engineer is the inspection of materials for culverts and bridges. Should the aggregate be produced locally it is necessary to test for silt content and organic matter, and in the case of the coarse aggregate, graduation of pebbles. Even in the case of aggregate secured from commercial plants we sometimes find it necessary to run a few tests, where the material looks doubtful.

Metal culvert pipe for the ensuing season will have to be checked as to gauge, size, proper amount of spelter, proper lap and condition of rivets by the division materials engineer, who will also take samples of the pipe for a chemical analysis. Only after this is done and the results found satisfactory will the pipe be considered O. K. The scope of duties also calls for some attention to be paid to the problem of dust prevention, not alone from the standpoint of public safety but also from the standpoint of conservation of materials.

We have also taken screen analyses of different crushed material which was placed on various projects in an attempt to determine just what effect the gradation of materials has with regard to wash boards. This data has been plotted, and the resulting curves are rather interesting from that standpoint, although we have not yet enough different jobs to arrive at any definite conclusion.

Office Duties.—As the materials engineer is in possession of all of the data concerning materials, he is the logical source of information regarding it. Consequently, he is in a position to prepare all estimates concerning gravel surfacing, and this includes clearing, grubbing and stripping the pit, sand removal, loading, screening, crushing and hauling. He should also be in a position to prepare estimates in regard to top soil, loose and solid rock. He should be able to state offhand whether or not there is a possibility of local aggregate in bridge or culvert construction, or where the most likely source is apt to be.

All the information or data pertaining to materials, which has been gathered by the road materials parties or the materials engineer, must be recorded in an orderly fashion in the office. We have in Division No. 8 a large map of the division on which all gravel deposits located by road material parties or the division are indicated by numbers. Corresponding numbers appear on cards which contain all the important data concerning that location. These cards are filed by counties and are kept in a Kardex case. This enables any one to get the location of a material deposit by consulting the map, and then in a few moments gather all the data from the cards. We are making an attempt to secure all data on county owned pits and include this in our system. With reference to the map, we have found the use of colored map tacks very helpful, inasmuch as they may be used to indicate exhausted pits, worthless deposits, proposed pits for the season, etc. It is obvious that unless this data is brought up to date each year it will soon become obsolete.

In conclusion let me say that it is highly important for the materials engineer to look ahead and consider just

what the materials situation will be over a period of 5 or 10 years, keeping in mind that one important fact that materials are continually being exhausted without showing the slightest sign of being replenished. Let me urge that plant set-ups be so governed as to make the most of the situation—i. e., to take every bit of material before the pit is finally abandoned. So often you see a pit where the heart of the material has apparently been gouged out, leaving a few hundred or a few thousand yards on either side which might be considered inaccessible. This is practically true in localities where gravel is so plentiful that the common supposition is that it is almost inexhaustible, but bear in mind that some day the very pits which have been so abandoned will be reopened in hopes of gaining a few hundred yards of material, and the oversize material which has been wasted in pits will be crushed to size. Remember also that material which we now scorn because of its inferior quality will some day be considered a life saver, and as a final word let me urge the counties to purchase as much material as they conveniently can even though they have no immediate use for it, bearing in mind that it will never become any cheaper than at the present time but on the contrary will become more and more expensive as time goes on.

Colorado Puts New Patrol System in Effect on Federal Aid Roads

On May 1 the State Highway Department of Colorado took over the maintenance of all its Federal Aid highways. In the past this work has been done under the supervision of the county commissioners, the counties and the state dividing the cost. This system proved unsatisfactory to the U. S. Bureau of Public Roads, which demands that the Federal Aid net work be kept up to a certain standard. Some details of how the state will handle the maintenance work are given in the April issue of Colorado Highways, from which the matter following is taken.

The state has purchased $390,000 worth of road equipment, including 73 tractors, 100 graders, 40 maintainers, plows and hand tools. The state also has 40 trucks for use as power units for maintainers and for hauling gravel.

Maintenance forces will be divided into 125 crews of two men each, each crew, with approximately 25 miles of Federal Aid road to patrol regularly, insuring steady efficient maintenance of each Federal road, which bear the most travel of any of the Colorado highways.

During the last 30 days the equipment has been received and distributed in all parts of the state. The larger power units have been assigned to patrols located in the higher altitudes, while the smaller tractors were distributed in the plains counties. The graders were of 7 and 8-ft. blade capacity, while the tractors range from 20 to 40 h.p.

Traffic surveys made by the department during the past two years show that nearly 85 per cent of all the motor traffic in the state is served by the Federal system. The sum of $1,000,000 was set aside in the budget for maintenance in 1928. In counties having now Federal roads, the state will share the cost of maintenance on a 50-50 basis. There are eleven such counties.

Each patrol crew will be provided with a tractor or a truck and a grader or maintainer, together with other necessary equipment. These crews will be employed throughout the year. They will be kept constantly at work on their particular section of road.

The graders are all equipped with scarifiers. With these the rough places on the roads may be scarified and then smoothed out with the blade machine.

Forty government army trucks, bought by the department at nominal prices after the war, have been completely rebuilt and reconditioned. Some of these trucks had never been uncrated and were in the same condition as when shipped from the factories. They are 2 and 3-ton capacity.

So far as possible the crews employed by the state have been men who live in the locality where they will be stationed. The majority are men who formerly were employed by counties and are experienced in the work which they will be required to perform on the Federal Aid system.

To those crews who will be employed on concrete pavement maintenance the department has sent the following memoranda, stressing the importance of their task:

It should be no small part of the task of organizations engaged in the construction of highway systems to give "service" on the roads after they are built. The motorist who learns to depend on service stations operated by the manufacturer of the car he drives has the same right to expect careful and constant maintenance of the road over which he travels. Also the taxpayer who pays for the pavement is entitled to the utmost protection of his investment.

Concrete pavements, like all other types, must be maintained to give maximum service. There is in many quarters a tendency to take it for granted that concrete will stand up without attention; a tendency which is not warranted by the ratio of cost of maintenance to the first cost of construction.

Too much stress can not be laid on the desirability of early maintenance; that is, the careful inspection and necessary repairs during the critical period of the first year after construction. This would include first of all the most obvious need of keeping the joints and cracks filled with bitumen. Less obvious is the necessity of watching for the subgrade failures which are usually the cause of breaks in concrete pavements when they occur. Maintenance of shoulders is essential to prevent settlement of the subgrade along the edges of the pavement. On new pavements careful watch should be kept of points of subgrade weakness such as points of change of grade, approaches to bridges and culverts, points where cut sections change to embankment, sections known to be laid on subgrade of doubtful bearing power and edges of pavement on heavy fills or side hill sections. By prompt discovery of settlement or heaving of slabs or settlement of subgrade at edge of slab, the defect can be remedied at slight cost before a succession of heavy loaded vehicles breaks the pavement slab.

Improved Highways Little Damaged by Mississippi River Flood

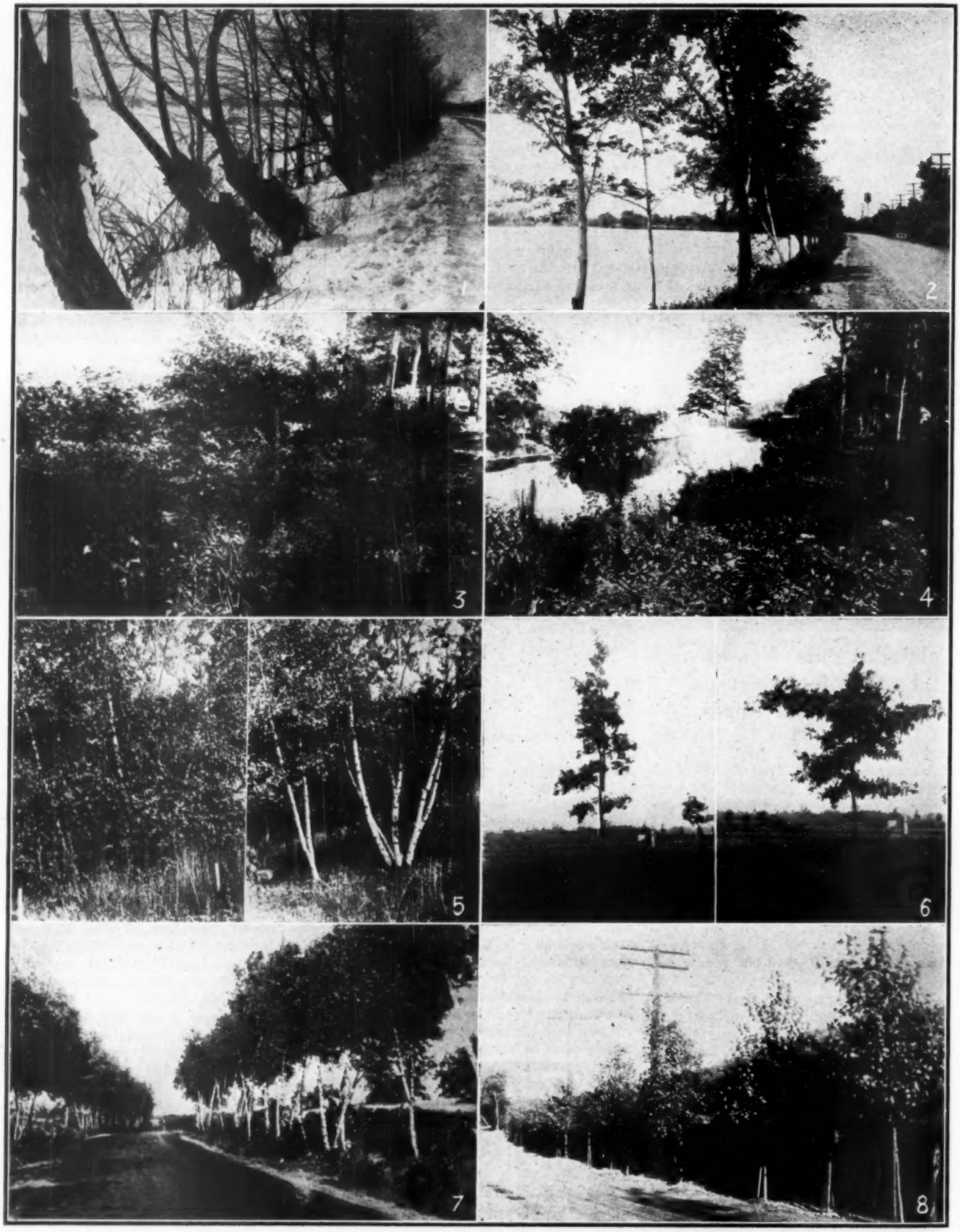
Highways and bridges in the flood districts of Illinois, Missouri, Kentucky, Tennessee, Arkansas, Mississippi and Louisiana were damaged to the extent of $3,949,900 by the recent overflowing of the Mississippi River according to the American Road Builders' Association.

Improved highways withstood the onrush of water without serious damage, the association asserts. Roads without improvement were in many cases virtually wiped out, causing an expensive delay in traffic and curtailing the movement of necessary food and shelter supplies. Bridges were completely destroyed in sections where the foundations were not constructed to withstand the swift moving waters.

The damage to public highways and bridges has been estimated at $2,738,-100, and the damage to privately owned roads and bridges at $1,211,800. The loss constituted less than 1.7 per cent of the estimated flood losses of $236,-334,414 as compiled by the Port of New Orleans. The most serious loss in the flood was that of growing or newly harvested crops which totalled approximately $73,541,000.

The American Road Builders' Association urged the immediate construction of an adequate highway system designed to withstand the maximum flood waters in those sections subject to overflow. The existence of these roads, it was stated, will facilitate the salvage of personal property, protect human life, and permit speedy reconstruction of damaged areas.

Good roads in the Florida counties struck by the hurricane last year were opened for motor travel within a few hours after the storm had subsided. The quick movement of first aid supplies and rations over these roads unquestionably was responsible for the saving of many lives, it was said.



Some Illustrations of Improvements Affected by a Little Landscape Work Along Massachusetts Highways

(1) An Old, Rotten and Unsightly Growth of Stumps, and (2) Stumps Removed Allowing Rapid Development of the Secondary Growth (3) and (4) Before After Views of Landscape Cutting (5) Developing a Group of Birches (6) Showing How Tree Surgery Can Improve Trees of Undesirable Shape (7) Grey Birch, with Brush and Lower Limbs Removed for Trunk Emphasis (8) Landscape Greatly Improved by a Tree Planting Along a Board Fence

How Massachusetts Is Improving Her Roadsides

General Plan of Beautification and Methods of Handling the Work

R. E. TRIBOU
Assistant Highway Engineer, District 9, U. S. Bureau of Public Roads

THE Massachusetts Department of Public Works is empowered by law to make roadside improvements, the work including such plantings, replacements, and care as may be necessary. When a road is laid out as a state highway, it is generally made sufficiently wide to provide an area on each side of the traveled portion for roadside improvement. No tree, shrub or plant within such a highway can be cut, removed, or new ones added without a permit from the highway department.

The work of roadside improvement is done by the maintenance division of the department of public works, which is in charge of G. H. Delano, Highway Engineer. The cost is included as a part of the regular maintenance expenditure of the State. The State has a nursery at Palmer, Mass., where trees and shrubs are propagated and where J. H. Taylor, Highway Landscape Supervisor, trains men in the care of trees and roadside beautification. This nursery is a part of the maintenance division. The following outline shows the scope of the work being done.

The work of roadside treatment which Massachusetts started in 1921 has within a relatively few years produced a marked effect on the beauty of its highways, which will be even more striking in future years. Massachusetts is one of the few states where organized attention is given to roadside beautification, and because of the general interest in the subject it appears to be worth while to present a short description of the general plan of beautification and methods of handling the work which have produced good results on a considerable mileage of road at a very reasonable cost. We accordingly are reprinting an interesting article on this subject from the April issue of Public Roads, the official publication of the U. S. Bureau of Public Roads.

Attention to Native Material

Removal of Dead Material.—Dead and dangerous branches are systematically removed. Trees entirely dead are removed and stumps cut 6 in. below the ground surface.

First Aid to Injured Trees.—Mechanical wounds to trunk or branches are trimmed and sealed with tar. Trees split or in danger of splitting are fastened with bolts or cables. Open cavities are suitably repaired.

Care of Trees.—Unsightly, abnormal, or rubbing branches are removed. Pruning and shaping is done by trained men. Spraying is done when necessary. Preservation and culture of natural growth is important work. Intelligent care of this sort will add much to the future beauty of roadsides.

Safety Work.—Standard traffic clearance is maintained.

Landscape Cutting.—Vistas of mountains, lakes and streams are developed by removal of foliage screens.

Wire Clearance Work.—The state supervises all tree trimming for passage of public service wires and prohibits careless and unnecessary cutting.

Public Enjoyment and Education.—Roadside springs are made available to travelers. Benches are provided in suitable places. Public cleanliness is invited by placing rubbish barrels.

Introduction of New Material

Healing Construction Scars.—Gravel and sand slopes are planted with small pines or other adaptable ground cover. Grass or shrubs are planted where the soil will support growth.

Tree and Shrub Planting.—Trees, shrubs and vines adapted to soil conditions are planted on roadsides, traffic islands, behind guard rails or stones.

Replacements.—Historical and normal growth is perpetuated by annual replacement of the dead with the living.

Maintenance.—The success of all planting depends solely upon maintenance. Young trees and shrubs must have care. The future beauty of trees depends largely upon their training in youth, which means that trees should be staked and pruned annually and intelligently. Shrubs must be cut back properly to insure a graceful maturity and soil about the base of all planted stock kept open for proper moisture and air. Such work is imperative and must be done regularly.

The men engaged in this work are advised to study how nature plants and imitate it as far as possible. The object is to keep the roadsides as natural as possible by the use of native material. A Colorado blue spruce on a Massachusetts roadside is distinctly out of place and artificial, since it is not characteristic of Massachusetts. Importations may be attractive but they do not reflect the personality of the State.

Plantings on roadsides are mainly confined to new construction for several reasons. The wider locations (60 ft. or more) give more opportunity for scenic development, and these relocated and widened roads promise a fairly undisturbed future. Shade trees are planted as near as possible to the side line, but for the most part the monotony of straight lines and even spacing is avoided. Grouping of trees and shrubs is at all times preferable.

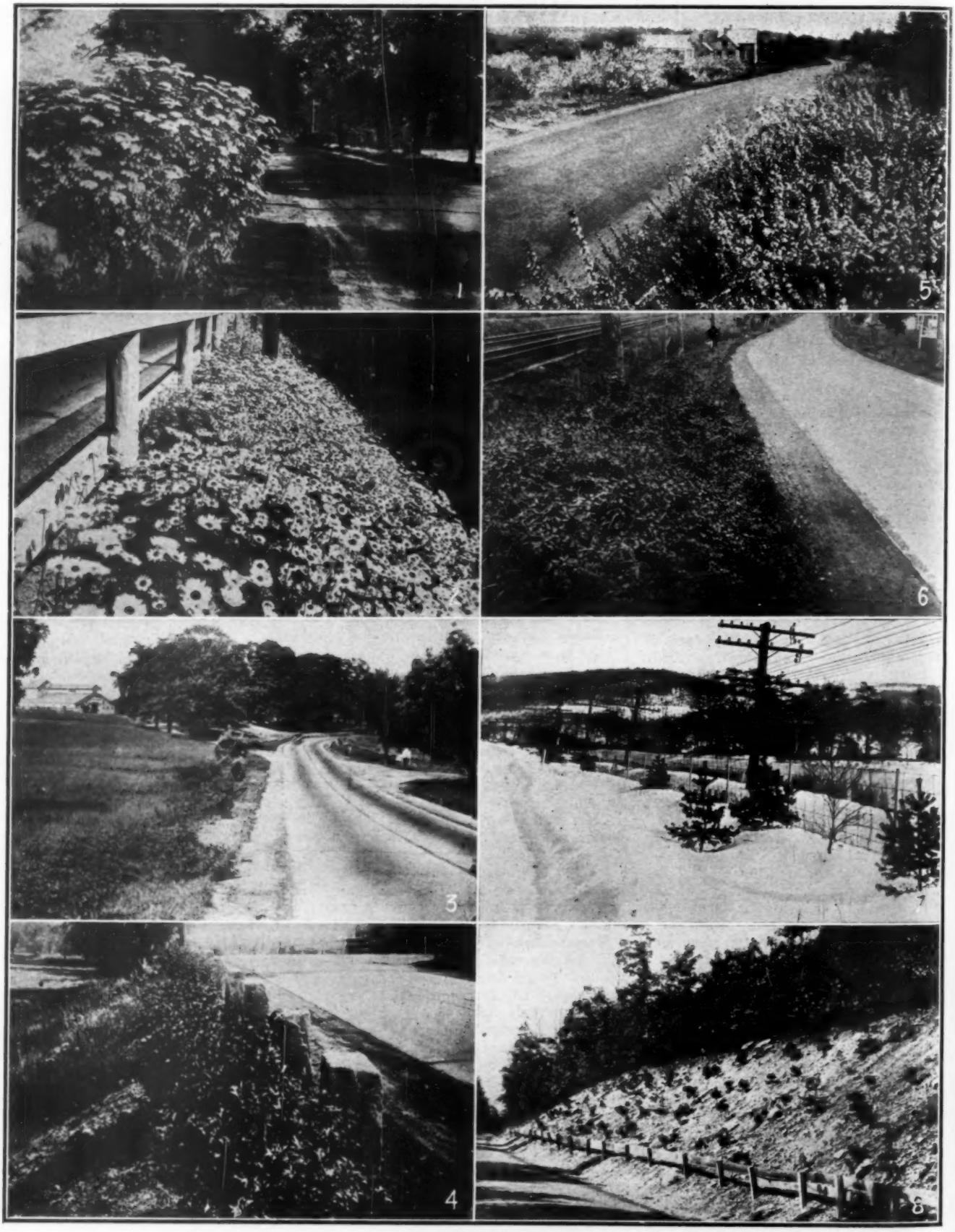
Planting Procedure.—After a construction job is completed the plan of treatment is determined by an employee trained in the work, who locates the various plantings on a blue print of the layout, using colored pencils. Next the ground is staked for digging. Digging costs are decreased 50 per cent and an extended area is stirred up when holes are blown by dynamite. Pits are filled with the best soil obtainable.

An order for the necessary planting material is forwarded to the nursery and the material is delivered by trucks and trailers. Plantings are carefully made, giving the trees or shrubs every opportunity to get a good start and each plating is staked. After the planting has become well established a final grubbing is given.

The results which are being secured are best described by the accompanying illustrations which were taken by J. H. Taylor, Highway Landscape Supervisor.

Uniform Day for Opening Bids

Wednesday has been selected by the California State Department of Public Works as a uniform week day for the opening of bids on construction work. The selection was made by B. B. Meek, director of the department, at the request of the contractors of the state. It was stated by the latter that Monday, the day upon which bids have previously been opened, worked a hardship upon contractors in that it conflicted with county and city bid openings. It was also urged by contractors that it was sometimes difficult for them to make the required banking arrangements at the end of the week in readiness for Monday and on that account added several days' bank interest. The difficulty of securing material quotations at the end of the week was also given as a reason for making the change.



Examples of Roadside Treatment Along the Highways of Massachusetts

(1) The Elderberry Is Worth Saving (2) The "Glory of Common Things" (3) A Border Planting (4) Softening the Harsh Lines of Protective Stones (5) A Beach Plum Border on Cape Cod (6) An Unsightly Gravel Bank Which Has Been Covered with Honeysuckle (7) Evergreen Plantings Liven the Winter Landscape (8) Pine Planting on Untreated Bank

Formation of City Officials' Division of the American Road Builders' Association

With the success that attended the formation of the Division of County Highway Officials of the American Road Builders' Association, it was clearly demonstrated that it was logical for the association, through various divisions, to represent the entire highway industry.

At the last convention of the Road Builders' Association, the County Highway Officials' Division plainly brought out the value of such divisions in the work of the association. On County Highway Officials' Day the program of the convention was conducted by county highway officials and consisted of representatives of the various committees, whose reports were the result of nearly a year's work of engineers located throughout the United States. The interest displayed was exceptional and the value of the reports as a standardization medium was quickly recognized by county officials.

The directors of the American Road Builders' Association, acting upon the request of several city officials, authorized the formation of a City Officials' Division of the American Road Builders' Association. The division will be governed by its own constitution and by-laws and will elect its own president, vice-presidents and directors. It will retain the identity of a city officials' organization but will remain a division of the American Road Builders' Association. In addition to the president, vice-presidents and directors, the division will operate through contact men located in all the principal cities of the country.

The policy of the Division for the present will be to apply itself to the street and highway problems of cities. There will be several committees appointed, made up of city officials from different cities throughout the United States, and the reports of these committees will be presented on City Officials' Days at the next convention.

There are many problems within the cities that are still demanding the best attention of engineers. With the formation of the City Officials' Division, it is expected that many details which now lack agreement will soon be standardized.

The organization meeting for the City Officials' Division will be held the early part of June at the headquarters of the association in Washington. It is urged that all city officials attend and take an active part in the affairs of the Division.

Gas Tax Increases Road Revenue in Maine.—The state of Maine will have an increased revenue of $700,000 a year, it is estimated, as a result of the law raising the tax on gasoline from 3 to 4 ct. a gallon.

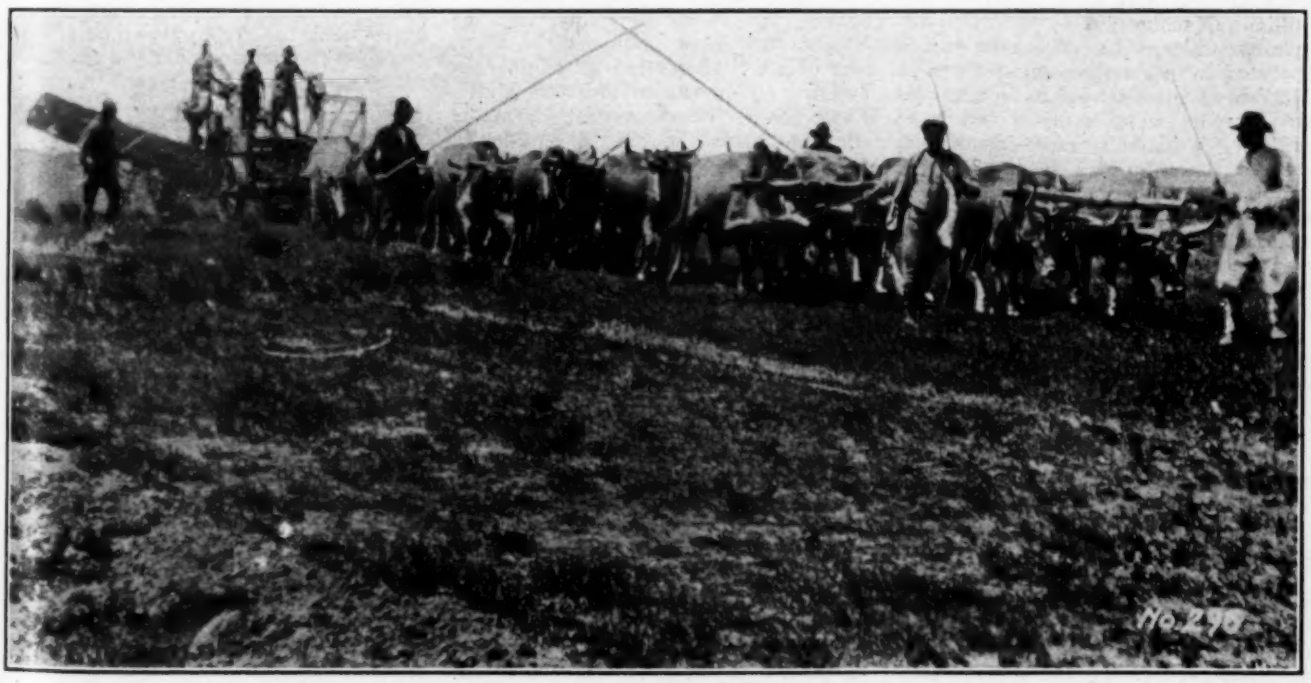
Recent Accomplishment of Road and Paving Material Committee of Am. Soc. Testing Materials

The spring group meeting of the committees of the American Society for Testing Materials was held at Washington, D. C., on March 21, 22, 23. The following is a summary of the work of Committee D-4 on Road and Paving Material:

At the meeting of the committee held on March 23, interesting developments were reported in connection with both bituminous and non-bituminous materials. Among the former a complete form of practice for the inspection of bituminous paving plants engaged in the production of all classes of bituminous paving mixtures was presented and recommended for adoption.

The section having charge of the development of a new distillation test presented a report showing marked progress in establishing the accuracy and adaptability of the new distillation test when carried on by a number of different operators. The method of demonstration consisted in gathering in a single laboratory, representatives of a number of state highway departments and several large industrial organizations who conducted the test simultaneously on identical samples with very concordant results.

Along non-bituminous lines, a report dealing with materials, proportioning



Old Fashioned Power Moves Modern Machinery in Brazil

The view above shows a Stroud elevating grader on a road job at Porto Alegre, Brazil, South America. This outfit, owned by the State Government of Rio Grande do Sul, the southernmost province of Brazil, is shown being pulled by 14 oxen, or "bulls," as they are called throughout the tropics. It is an odd case of modern machinery operated by an age-old motive power, and is typical of a great deal of work in the south. The oxen are driven by 5 men who use long pointed poles (goads) or, as they are sometimes called, "prods," to keep the "bulls" on the move. One man is used on the grader, and the other two men shown riding the grader in this picture happen to be visitors. Yoke of oxen make reliable and cheap motive power in climates where the heat would even cut down or destroy the usefulness of the mule and where repair facilities for tractors may not be available nearby. While slow, a yoke of bulls will usually give consistent progress and plenty of power. Another advantage besides their ability to work under excessive conditions of heat is that they give but little trouble and can be turned loose at night to live off the country. Tractors, however, are fast supplanting them in the tropics.

and curing methods for portland cement concrete pavements and bases was presented and recommended for publication with a view to eliciting criticisms, which should make possible the preparation of a detail specification for these features of concrete pavements and base construction within about a year's time.

Following the regular meeting of Committee D-4 an organization meeting of the newly created Sectional Committee on Methods of Test for Road and Paving Materials, functioning under the procedure of the American Engineering Standards Committee, and whose personnel is identical with that of Committee D-4, was held; at which it was voted to submit the following A. S. T. M. methods to the A. E. S. C. for approval as American Standard, subject to approval by letter ballot vote of the committee: For Determination of Bitumen, for Penetration of Bituminous Materials and Float Test for Bituminous Materials.

Julius Adler, Consulting Engineer, 1228 Spruce St., Philadelphia, Pa., is chairman of the Committee and Prevost Hubbard Chemical Engineer the Asphalt Association, 441 Lexington Ave., New York City, is Secretary.

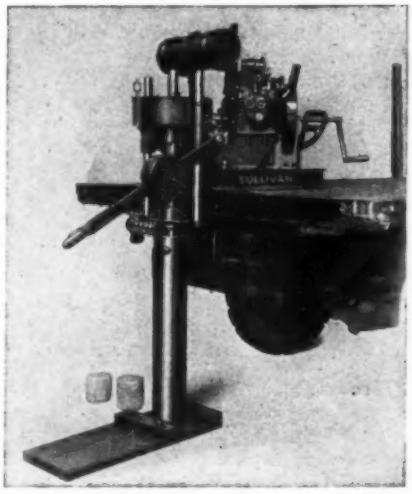
New Core Drill for Pavement Testing

A new core drill for removing cores of concrete pavement to permit inspection of its structure, materials and thickness has been brought out by the Sullivan Machinery Co., 92 East Adams St., Chicago Ill. This new drill is operated by a gasoline engine, weighs 772 lbs., and is intended to be mounted on the rear end of a motor truck. It drills a 6⅝-in. hole, removing a 6-in. core at the rate of 1 ft. in 15 to 20 minutes. A 7-in. pavement has been penetrated in nine minutes. This speed enables it to take from 20 to 30 samples per 8-hr. day. With the core barrel usually furnished, this machine will drill to a depth of 18 in.

The core drill consists of a drive rod rotated through bronze worm gears by a direct-connected gasoline engine. The drive rod is kept in alignment by substantial side rods connected to a crosshead at the bottom of the drive rod, and running through cylindrical sleeves which are cast in one piece with the heavy bedplate or frame supporting the drill and engine.

At the lower end of the drive rod is a spider to which the core barrel, 6 in. in diameter, is bolted. The drill is fed downward automatically by means of a double rack cut on the side rods referred to, and double pinions. The speed is controlled by a hand lever which is weighted, the weight being shifted in or out on the lever as desired, so as to secure the proper pressure on the core barrel for drilling.

The crosshead is equipped with a ball bearing which takes both the radial and thrust loads and provides a very rugged and rigid support for the barrel.



Sullivan Pavement Testing Core Drill in Drilling Position

The drive gears at the top of the drive rod mesh with the drive gear on the end of the shaft of a Buda 6 h.p. two-cylinder opposed type, air-cooled engine, and the gears are totally enclosed, running in a bath of oil.

Heavy Duty Engines for MultiFoote Pavers

As highway engineers and contractors have shown a decided preference for heavy duty, six cylinder engines on pavers, the Foote Company, Inc., of Nunda, New York, announce the adoption of six clinder Hercules engines as optional equipment on the 1928 MultiFoote pavers. The heavy duty Hercules engines have proven exceptionally sturdy and dependable in their extensive use on buses and trucks in the automobile field, according to the manufacturers. However, the Foote Company tested and tried out the engines under actual operating conditions before equipping a 1928 MultiFoote with the Hercules engine and exhibiting the equipment at the Cleveland Road Show this year. Deliveries of pavers using the heavy duty Hercules engines were started shortly after January 1.

Probably the most noteworthy advantage brought about by the optional equipment is the excess power produced by the Hercules motor. The type used, Y X C of 4⅜ in. bore and 4¾ in. stroke, develops 60 h. p. at 1150 r. p. m.—the speed at which it is ordinarily operated—but it can develop 75 h. p. at 1480 r. p. m. without harm or excessive vibration. Since it has been found that 60 h. p. gives a large power surplus for most operations, the Y X C model can handle the usual loads so easily that there is very little wear and tear on the motor. This will give exceptionally long motor life and eliminate many delays usually caused by adjustment or replacement.

The new addition to the engines now provided for the MultiFoote pavers is reported to be one of the best built and has the excellent features of a seven bearing crank, built in governor, oil filtrator, alloy steel cylinder block, and a large 3 in. diameter crankshaft. At the same speed the Hercules engine is capable of developing 50 per cent more power than engines formerly used.

Special attention has been given the problem of efficient cooling and in the new engines water, driven by a water pump delivering 46 gallons of water per minute at 1,000 r. p. m., is directed in a stream around each exhaust valve. The top of the guide comes close to the head of the valve, thus bringing the jacketed portion of the guide near the valve head. Also the design of the crankcase gives unusual rigidity, as it is integral with the cylinders.

By the addition of the heavy duty six cylinder Hercules the Foote Company now has three different motors, presenting a wide range to take care of any highway builder's needs. However, the bulk of their demand for pavers during the last year was for pavers with six cylinder engines capable of heavy duty, and the increasing call along this line is expected to favor the excess powered MultiFoote paving layers. The Foote Company pioneered in the use of six cylinder engines on pavers, and they now claim to be the first manufacturers to adopt a real, heavy duty, six cylinder motor. The modern trend is for sturdier, more dependable, and more economical machines—according to the Foote engineers—and the 1928 MultiFoote was designed to operate under the most adverse conditions at maximum capacity without slowing up the work of placing concrete.

A New Auto-Strada for Italy

An announcement has been made that the national government of Italy has officially approved the construction of an "auto-strada" (automobile highway), to connect the cities of Florence and Viareggio, according to a report from Consul Joseph E. Haven released by the Department of Commerce. This "auto-strada" will be similar in general respects to that connecting Milan with Como and will cover a distance of 84 kilometers (51 miles). From Viareggio to Leghorn a good road is already in use, so that in reality the new highway will give direct connections between Florence and Leghorn, passing through Empoli, Pontedera and Pisa.

The period of construction will occupy three years and the cost is estimated at 90 million lire (about $4,640,400), half of which is already subscribed by the various cities and towns along the route. The new highway will be used exclusively by automobiles and the cost of upkeep, together with interest on the investment, will be obtained from the fees or tolls collected from motorists.

Black Base in Southern States

Extract from Paper Presented at 6th Annual Asphalt Paving Conference

By WARREN H. BOOKER
Consulting Engineer, Charlotte, N. C.

BLACK base in the South is neither a novelty nor an innovation. Some of the earliest black base laid in the South was a project of approximately 30,400 sq. yd. on Liberty St., Savannah, Ga., in 1889. This pavement was resurfaced in 1908 and from a recent report, the pavement is in good condition and rendering excellent service today. Although asphalt streets were laid in Washington, D. C., as early as 1876 the use of bituminous concrete as a base course in the Southeast probable dates back to the laying of the Savannah project thirty-eight years ago. The black base pavements in Washington are the oldest of the type of which I am aware. Many thousands of yards are now in existence and range in age from 35 to 45 years.

Today black base, in some form, is being laid in nearly every Southern state, and within recent years the amount laid each year has been increasing by leaps and bounds.

As previously stated, black base is closely allied to other forms of flexible construction.

The true black base pavement is one composed of a coarse aggregate asphaltic concrete only, as a base, usually with some approved type of asphalt wearing surface, laid directly on a stable earth sub-grade. The dimensions of this type for the heaviest traffic should be 4½ in. of black base and 1½ in. of wearing surface. Although for medium traffic the thickness of this pavement can safely be reduced to 3½ in. of black base with a 1½ in. wearing surface. In state highway construction an inverted harder curb of black base should be used. In city work the curb and gutter suffice.

Triaxial Diagram for Black Base.—For several years the writer has used very successfully the little triaxial diagram issued by the Asphalt Association for selecting and proportioning sheet asphalt sands. This little diagram has proven a convenience, a great time-saver and a ready means for not only setting the original mix but more especially, for considering extraction tests and comparing laboratory results with specification requirements and directing the necessary modifications of the proportions to meet the ever-changing size gradings found in the stock piles.

On a recent black base project, the writer took occasion to adopt this same triaxial diagram to similar uses in connection with black base work. Since the usual specifications for black base call for a 3-size grading by percentages of weight, this triaxial diagram, it will be seen, can readily be adopted for proportioning mineral aggregates for black base as well as sands for a sheet asphalt mix. In fact, this triaxial diagram can be used with any mineral aggregate regardless of size, just so there are 3-size gradings governing.

In the usual specifications for complete black base mixes the three sizes of mineral aggregate by percentage are from 15 per cent to 45 per cent of coarse material ranging from 1½ in. to ¾ in. in size; 15 per cent to 45 per cent of intermediate material ranging from ¾ in. to ¼ in. in size and 25 per cent to 40 per cent of fine material passing a ¼-in. screen together with from 4 per cent to 7 per cent of asphalt cement. These percentage limits for mineral aggregate alone allowing 5 per cent for asphalt cement have been plotted on the triaxial diagram to adopt it for use for black base.

As in the case of sheet asphalt, the limits of the standard specifications are rather wide, which tend to make it comparatively easy to get a sheet asphalt or black base mixture to come within the specification limits. By means of the triaxial diagram any particular sand, gravel, stone or combination of aggregates is represented by just one point readily ploted on this chart and from this point one is able to see at a glance not only just which way and how much the mixture differs from the ideal but just what material and how much is needed to make the resulting mix more nearly approach the ideal mix desired.

The Sub-Grade.—In laying black base, perhaps the greatest single consideration should be for sub-grade. In general, the sub-grade in the South is usually either a sandy, gravelly material from which the water drains readily, except where the adjacent land is wet, swampy and undrained for at least a portion of the time; or else the sub-grade is a close, dense, clayey material from which the water drains with difficulty.

Black base is admirably adopted to the latter case and is coming to be used more and more where the former type of material is encountered.

Improving Sub-Grade.—In the case of sandy, gravelly, or but partially drained soils which cannot be compacted by rolling or ordinary methods the remedy is to be found very largely in adequate drainage in one or more of the various forms ordinarily used, and especially, by filling in with suitable material and raising the elevation of the sub-grade well above any possible water level.

Where adequate drainage is impractical, or where all or a large part of the sub-grade is spongy and cannot be readily compacted by means of a 10 to 12-ton, 3-wheel roller, a black base is not to be recommended unless the sub-grade can be in some way improved or rendered capable of adequately supporting the pavement.

As a means of improving wet sub-grades, it is surprising to note the effect of placing a roof of water-proof bituminous pavement upon a questionable sub-grade. In many instances, sub-grades that are ordinarily too wet become entirely satisfactory for sub-grade purposes after they are covered with a roof of water-proof black base and pavement. It is well known that more trouble results from wet and softened sub-grades resulting from cracks and leaks in the pavement than from lateral percolation into the sub-grade under the pavement.

In cases of local, soft, spongy places where stumps have decayed or where holes or ditches have been filled with organic or other objectionable matter, the remedy is simply to replace this matter or a sufficient amount of it with good sub-grade material, thoroughly compacted.

In other places the sub-grade can readily be improved by means of a broken stone sub-base, clay-filled gravel, or similar material compacted to a depth of from 2 in. to 5 in., as the local condition may require, Such a sub-grade greatly improves the situation by increasing the bearing area and thereby reducing the unit loading on the sub-grade. In such cases the thickness of the black base can usually be safely reduced to from 2 in. to 3 in.

Green Fills.—Green fills are sometimes almost unavoidable. Frequently they must be made to support traffic on some form of pavement. In such cases where uneven settlements occur the flexible black base gradually conforms to the settled sub-grade without breaking, cracking or raveling, thereby deriving the maximum supporting power from the sub-grade. Where it is later desired to level up the wearing surface, this may readily be done at nominal cost by means of leveling patches without, in any way, disturbing the base. In addition to the leveling effect of these patches, by increasing the thickness of the pavement they materially increase the area of the bearing surface for the distribution of load or impact and correspondingly decrease the unit foundation loading over places of demonstrated sub-grade weakness.

Sewer Trenches.—Sewer trenches under city pavements, in the writer's experience, seem to give little or no trouble with the use of black base if the sub-grade and upper part of the sewer back-fill are thoroughly rolled and uniformly compacted. In rolling sewer or other trenches, where practical, an effort should be made to have one rear wheel follow down the old trench line, experience indicates that paticularly in narrow sewer trenches the arching effect, if the upper foot or more of back-fill is thoroughly compacted, furnishes surprisingly good sub-grade support. This statement is not

to be taken as a license to omit the tamping of back-fill in sewer trenches but rather to indicate that surprising strength of sub-grade is developed in spite of adverse conditions.

With further reference to the matter of sewers in city streets, it is the writer's opinion, that by reason of more or less infiltration of ground water into these sewers, the ground water level under pavements over sewer lines is in many places considerably lowered. This is particularly true in low places in streets where sewers are nearly always present and where the need for this unintentional element of drainage is usually greatest. This lowering of the ground water level greatly improves sub-grade conditions. With the arching effect at least in the upper part of the sewer trench, with the added improvement of drainage by infiltration into the sewer below and the still further aid of a water-proof black base roof above, little trouble need be expected from sewer trenches.

Water Trenches.—In the city street work, however, the matter of leaky water mains and service connections should be given particular attention. This past summer the writer was engineer on some 5 or 6 miles of black base work in a small town where the sub-grade consisted of dense, tight, almost impervious shale. The water mains had been laid entirely too shallow. A casual examination of the surface of the uncompacted sub-grade showed that at least one-third of the joints in these water mains were leaking. Some joints were leaking to an extent which would endanger any kind of a base on a sub-grade of shale which we know but a short time ago, geologically speaking, was simply mud and ooze. When rolling began, wet, quaking mud holes developed at intervals of 12 ft. or multiples of 12 ft. over these leaky joints.

In this case, the policy was adopted of first caulking the worst leaks in order to dry up the mud holes sufficiently to permit thorough rolling of the sub-grade and the back-fill in these water trenches. It was thought that this rolling and any consequent movement of the back-fill and water pipe, would develop all the leaks in the water mains that would ever give trouble. After this rolling, each bell hole was opened and the joint inspected. It was found that practically every joint was leaking to some extent. The lead joints were then recaulked until the leaks were stopped and the back-fill rammed into place. By this means, only two joints on the entire job gave any subsequent trouble.

Examples of Bad Sub-grade.—After all, the surprising thing about sub-grades for black base construction are the examples of the successful use of black base on sub-grades ordinarily considered as being not well adapted for this type of pavement. Take, for example, the Great Coastal Highway in South Carolina and Georgia. Here much of the sub-grade is fine sand with a considerable amount of finely divided decomposed vegetable matter. Of the 70 miles of black base construction on this highway thus far, over the better portion of the sub-grade a 4½-in. course of black base is laid with 1½-in. sheet asphalt surface, while in the worst sections a 3-in. course of black base with a 1½-in. sheet asphalt surface is laid on 5 in. of clay-filled gravel. In other sections, an original graveled roadway is salvaged to excellent advantage by applying a 3-in. black base to the old graveled way and using a 1½-in. sheet asphalt top.

C. N. Conner, Chief Engineer American Road Builders' Association

The American Road Builders' Association announces that C. N. Conner, of the Highway Research Board, has been retained as chief engineer of the association.

C. N. Conner, Chief Engineer, American Road Builders' Association

Mr. Conner has had wide experience as a road builder and exceptional experience as a committee worker. He has recently been chairman of the committee on Low Cost Improved Roads, operating under the Highway Research Board. Mr. Conner was graduated from Tufts College in 1908. For three years he worked as engineer in railroad construction, and later was assistant engineer with the Bureau of Public Roads in the Philippine Islands. His next position was assistant engineer with the War Department and then with the Navy Department. He then became assistant engineer with the Delaware State Highway Department, and after that was State Construction Engineer for the North Carolina Highway Commission, where he was also head of the testing and research laboratory for a brief period. During 1925 and 1926 Mr. Conner was chief engineer of the Mexican Federal Highway Commission. He is a member of several technical organizations and author of many articles which have appeared in technical publications.

Mr. Conner's work for the present will consist of co-ordinating the activities of the committees of the several divisions and arranging for the committee reports which will constitute the program of the next convention. The County Highway Officials' Divison, the Highway Contractors' Division and the City Officials' Division will operate through committees and their reports form the basis of the program for the next convention.

The American Road Builders' Association will organize in addition to its present committees several committees that will deal with problems of national interest. The program for the 1929 convention of the association will consist essentially of reports of the chairmen of the various standards committees. These reports will represent the work of the committees during the entire year, and every effort will be made to present them in a manner that is clear, interesting and concise.

The retaining of Mr. Conner as chief enigneer of the association marks another step in the development and usefulness of the association.

How to Prevent Cracks in Asphalt Pavements

Useful suggestions on raking and tamping at joints of asphalt pavements are given in a letter to J. E. Pennybacker, secretary and general manager, The Asphalt Association, by Jesse Henderson, an employee of the municipal asphalt plant of Cleveland, O. Through the courtesy of Mr. Pennybacker we are able to reprint his letter as follows:

"I believe I know what are the causes and where to lay the blame, in cracks that appear in asphalt pavements especially the joints.

"As I have been an asphalt raker for over 18 years, quite naturally I've noticed this before. But for the past three years, by working for the Municipal asphalt plant at Cleveland, has given me the chance to experiment and test out my theory.

"You know practically all cracks, even if they don't extend across the joint, will start from the joint. Some of the causes are varied, such as merely painting and overlapping of joints, other than sheet asphalt. "But the main causes are in the raking and tamping.

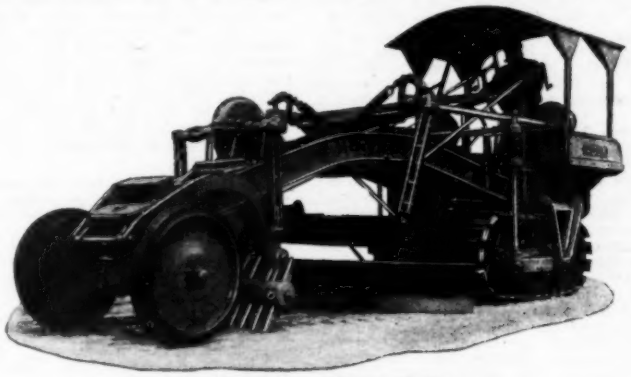
"A raker should pack his joint with his rake and comb it thoroughly, and have his tamper tamp it properly and soundly, 'to compact it,' and seal his joint with the tamper, then the smoother should finish, 'although not needed,' burning or grafting hot and cold joints together.

"As it is a raker usually combs his stuff on top, leaving that next to the base, just like it was shoveled making it look alright on top, but the trouble is underneath and can't be seen until cracks appear. They will work down or across the sheet underneath to a weak place on top, then the weather does the rest. And as for cracks straight across the joint, a tamper usually just tamps a few light licks, don't seal his joint and a smoother comes along and fixes it up. Now all a smoother does when he does this is just merely bringing the asphalt cement out to shine, if he comes to a hole or a nest of honey combs he just smooths a little over. It makes it look alright for the present, but in a short while your joint is bound to open up, and then it will extend in all directions.

"Also quite a few cracks can be laid to not properly rolling."

Galion Announces Caterpillar Tractor Powered Grader

One of the interesting features of the Road Show at Cleveland was the new Galion Heavy Duty Motor Grader with the Caterpillar 2-ton Tractor as the power unit. This new Motor Grader combines the power, dependability and positive traction of the Caterpillar with proven Galion Motor Grader frame, blade and operating parts, say the manufacturers.



The New Galion Motor Grader

Cast steel brackets form the main attachment between grader and tractor while the attachment at front of tractor is by means of a spring-mounted yoke. Four clamps and a few control extensions removed, makes it possible to raise the grader frame and remove the tractor for separate use. Assembly is equally simple. The Motor Grader parts include many Galion developments one of which is the new firm-balance front block which, while permitting all necessary freedom of motion for the front axle on uneven ground, removes all swinging of the frame on the front axle mounting, which tends to cause uneven blade action. Machine-cut E-Z lift gearing operating in oil at the bottom of an oil tight gear case, sturdy lift springs, 40 inch lift wheels, extra curved mouldboard, in 8, 10, 12 and 14 foot lengths, machine-cut worm for side shifting mouldboard, enclosed worm steering gear and many other proven features combine to make this a very satisfactory and easy operating motor grader.

The field of this grader is extended and its usefulness increased by the three following practical attachments:

The Scarifier that is controlled from the operator's platform by machine-cut worm gearing operating in oil.

The Snow Plow which is attached to the front end of the grader and operates in connection with the blade to open a wide path through drifts and fairly deep snow.

The Multiple Blade which is attached instead of the regular blade for certain types of maintenance work.

The comfort of the operator on this motor grader has been served not only by ease of operation and accessibility of controls but also by a sturdy shelter cab, with curtains when desired, and heavy fenders over tracks.

The uses of this motor grader are almost unlimited. It is primarily used of course in road maintenance. It will level roads and restore grades very rapidly, it is said. It will also maintain berm at the sides of paved roads, peel sod at road-sides, and clean ditches, say the manufacturers.

Contractors will find this grader very valuable in levelling subgrades, spreading and levelling road surfacing material, levelling fills and similar work, according to the manufacturers. In addition to this the attachments are said to make this grader very satisfactory in maintaining surfaced roads, and in moving snow. A new bulletin describing this grader will be mailed promptly on request to the Galion Iron Works & Mfg. Co., Galion, O.

St. Louis to Spend $12,000,000 on Paving and Sewers

The Supreme Court of the State of Missouri, on March 17th, 1928, handed down a decision validating the amendments to the City Charter of St. Louis, Mo., and removing the injunction against municipal contracts which had been in effect since the late summer of 1927.

The decision of the Supreme Court held the amendments to the St. Louis Charter valid in every respect and all ordinances passed thereunder to be correct, thus making it practicable for the banks to purchase special tax bills issued by the city under the new charter.

The city's program for 1928 involves the expected expenditure of nearly $12,000,000 on sewers and paving alone. Of the paving work, nearly $2,000,000 are now under contract and about $5,500,000 remain to be let, this work being divided in lettings scheduled weekly from this time forth. The first of the big lettings is set for April 24th, when bids will be received on asphalt and asphaltic concrete pavements in an amount of nearly $500,000.

The sewer work involving contracts for about $9,000,000 and probable expenditure of $4,500,000 during 1928 will also be the subject for receipt of bids during the spring and summer of this year. This program is over 50 per cent in excess of the greatest amount St. Louis has heretofore done.

New Miami Power Winch

The new Miami Power Winch, manufactured for attachment to the Fordson tractor, equipped with the Hamilton transmission, is shown on this page. This device attaches to the power take off of the Fordson tractor equipped with the Hamilton transmission. This winch is said to be of sturdy, rigid construction and to be capable of standing up under hard service. Full provision is made for proper lubrication and for the various strains and stresses to which it is subjected. Machine cut gears operate in a bath of oil. Hardened and ground shafts run on roller bearings. The drum measures 8 in. in length by 4 in. in diameter, holding 135 ft. of ⅜-in. cable. The speed of the drum is 60 ft. of cable per minute. The drum will develop a straight drawbar pull of 2,500 lb. safe load. The drum can be equipped with an overrunning brake for holding the load for an indefinite period where this is required.

The Miami Power Winch was designed primarily for operating the Miami One-Man Power Scraper, but may also be used for operating the Miami Back Filler, and Model MF-3 Power Hoist Rear Dump Trailer. It may also be used for stretching wire, operating hoists, hay forks, etc., where a winch of this type is required. It is manufactured by the Miami Trailer-Scraper Co., Troy, Ohio.

How the Power Winch Is Mounted on the Fordson Tractor

New Trade Literature

The following catalogs and other publications have been received from the manufacturers whose names are mentioned. Contractors, engineers, and officials concerned may secure copies for their information upon request to the manufacturers by whom they have been published.

Pneumatic Tools.—Chicago Pneumatic Tool Co., 6 E. 44th St., New York City, have published a new catalog of their pneumatic tools and accessories. This is a complete catalog and illustrates and gives data on balancers, busters, butts, chipping hammers, caulking hammers, chisels, clay diggers, demolition tools, grinders, hammers, hoists, riveters, rock drills, tampers, and other products. Ask for Catalog 561.

Paving Brick.—National Paving Brick Manufacturers Assn., 830 Engineers Bldg., Cleveland, Ohio, have issued an interesting booklet entitled "Brick Pavements in the Making." This publication is intended to show, by reviewing the processes of manufacturing and laying paving brick, the advantages claimed for this type of paving.

Tar.—The Barrett Company, 40 Rector Street, New York City, has issued a booklet "Tarvia for Road Construction, Repair and Maintenance," citing the advantages claimed for the material and illustrating quite a few jobs. They have also issued a booklet "Maintaining Roads With Tarvia" that makes a good handbook on this type of maintenance.

Loaders.—George Haiss Manufacturing Co., Inc., 141st St. on Canal Place and Park Ave., New York City, in an interesting bulletin recently issued, describe their Haiss 16 loader and such equipment as their swivel chute, precision hopper, and weighing hopper that can be supplied for use on the machine. Complete specifications are included. Ask for Catalog 328.

Heavy Duty Trailers.—Fruehauf Trailer Company, Detroit, Mich., in a recently issued folder entitled "Heavy Hauls," illustrate their line of heavy duty trailers that enable contractors to transport heavy equipment from job to job at high speed, and to haul heavy machinery over roads and streets. These trailers are designed for easy loading from side or rear and materially cut down the time required for moving construction plant.

Loaders, Shovels.—The Lessmann Loader Company, Des Moines, Iowa, have issued a new circular describing their high lift loader and low lift shovel. Besides giving a complete description of these machines, with specifications, etc., the circular tells how contractors and others have reduced their costs and revolutionized their methods with the Lessmann Loader and shovel.

Graders, etc.—J. D. Adams & Co., Indianapolis, Indiana, in their new Catalog No. 28, illustrate their line of adjustable leaning wheel graders and other grading outfit equipment. Full details are given, and the significance of various of their current patents is discussed by showing just what these patents mean in terms of reduced draft, closer work, easier operation, lessened wear, and so on. The information in this new catalog will be of interest to anyone interested in road grading and maintenance.

Elevating Graders—Wagons.—J. D. Adams & Co., Indianapolis, who now hold sole selling rights in the United States and Canada on Stroud elevating graders and dump wagons, have issued a new catalog describing this equipment in detail and giving some interesting performance data. This well gotten up catalog will be of real interest to dirt movers. In writing, ask for Catalog No. 28-S.

Rollers.—The Austin-Western Road Machinery Company, Chicago, has issued a new folder describing their worm drive rollers with scarifier attachment. Here are completely described the Autocrat, the Pup, the Bull Pup, and other three wheeled and tandem rollers manufactured by that concern.

Leaning Wheel Graders.—The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, in another new folder, describe their line of leaning wheel, telescoping axle, graders, of which they make several sizes. The circular dwells on the advantages claimed for these two features and gives specifications for the graders.

Motorized Road Maintainers.—The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, in a third new circular, tells about their line of motorized patrol equipment, describing each machine in detail and giving specifications.

Admixture for Concrete.—Celite Products Co., 1320 Hope Street, Los Angeles, Calif., have issued a bulletin on workability, entitled "Designing Concrete for Workability as Well as Strength." In this bulletin information is given on the use of Celite as an admixture in concrete and how additional strength is thus obtained by means of increased workability. The bulletin contains interesting data on this important subject.

Industrial Notes

J. S. Neibert, formerly Road Construction Engineer, Indiana State Highway Department, has been appointed District Engineer, Armco Culvert Mfrs. Association, and will be in charge of association work in Illinois, Indiana, Michigan and Kentucky. Mr. Neibert's earlier experience included positions as Chief County Highway Engineer of Bexar County, Texas, and City Engineer of Denton, Texas. In 1917 he joined the A. E. F., seeing active service with the 23rd Highway Engineers. Upon his return in 1919 he joined the Indiana State Highway Department as Project Engineer, rising shortly to the position of Road Construction Engineer. Since 1925 Mr. Neibert has been engaged in the contracting business. He is an associate member, A. S. C. E. Mr. Neibert will make his headquarters at Indianapolis and will extend Armco Engineering service to the states within his district.

The Hercules Motors Corporation in Canton, Ohio, report that on March 7 a frame auxiliary building adjoining their plant was destroyed by fire. The loss was minor, and operations in the main building, which is of modern fire-proof construction, have not been interrupted nor has production been retarded. The many users of Hercules Engines and personal friends of the Hercules organization will be pleased to know that there was no serious loss.

The T. L. Smith Company of Milwaukee, builders of Smith Mixers and Pavers, announce the appointment of the Service Supply Corporation of Philadelphia as their distributors for eastern Pennsylvania, southern New Jersey and northern Delaware. This organization has been prominently known in this field for some time and resident salesmen throughout their territory give them particularly close contact with the construction industry. A complete stock of mixers and repairs for both mixers and pavers place this organization in a position to render immediate sales and repair service.

Barber-Greene Company has recently established a new branch office in Cincinnati, Ohio. This branch is to be under the supervision of Mr. Paul Frederick, District Manager. Mr. Frederick has been with the Barber-Greene Company for nine years and comes to Cincinnati from the Barber-Greene office in Detroit where he had several years of experience as a Sales Engineer. The Cincinnati Barber-Greene office has the address.

The Kalman Steel Company has opened a branch office in Houston, Texas, under the charge of Mr. H. W. Goodman. Mr. Goodman has been transferred from the Detroit office of the Kalman Steel Company, and has been identified with the building industry for some years. The office will cover the states of Texas and Louisiana with headquarters at 938 Bankers Mortgage Building in Houston.

Joseph B. Shaw, who was formerly Deputy City Engineer of Utica, has been appointed District Engineer of the Eastern Paving Brick Manufacturers Association with headquarters at Utica, New York. Mr. Shaw is a graduate of Union College, and has had wide experience in engineering work, having been connected with the State Highway Department of New York and the City Engineering Department of Schenectady, and during the war was on the Technical Staff of the War Department, and later with the Bureau of Standards.

The Perfex Corporation, of Milwaukee, Wis, builders of heavy duty industrial engine radiators, announce the opening of a Cleveland office in the Leader Building. Mr. A. C. Owen, formerly located at New York, will be in charge of this office, taking over all the Ohio territory in addition to the Eastern states which he formerly covered.

Schramm, Inc., has opened new branch offices at 220 East Brady Street, Tulsa, Okla., 75 Fremont Street, San Francisco, Calif., and 192 Boylston Street, Boston, Mass., in order to facilitate the handling of the ever increasing demand for Schramm compressors.

The Pittsburgh Office of the American Hoist and Derrick Company will be moved from 1423 Farmers Bank Building to 604 Chamber of Commerce building, effective May 1.

The Timken Roller Bearing Service and Sales Company announce the appointment of Mr. W. H. Post as manager of the Pittsburgh branch office of the Company. Mr. Post has been with the Company for several years, during which time he has been active in sales work in the Cleveland district.

The American Hoist & Derrick Co., of St. Paul, has just appointed J. T. Seaver, Inc., Fairmount Cedar Building, Cleveland, Ohio, its representative for the Cleveland District.

Lorimer Dunlevy has resigned his position as Sales Manager for the Climax Engineering Co. of Clinton, Iowa, effective March 15th, to take on new duties as General Sales Manager for the O. E. Szekely Co. of Holland, Mich., makers of commercial airplane engines and other products now in process of design.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912,

Of Roads and Streets published monthly at Chicago, Illinois, for April 1, 1928.

State of Illinois } ss.
County of Cook }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared E. S. Gillette, who, having been duly sworn according to law, deposes and says that he is the Business Manager of the Roads and Streets and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Gillette Publishing Company, 221 East 20th St., Chicago, Ill.

Editor, C. T. Murray, 221 E. 20th Street, Chicago, Ill.

Managing Editor, H. P. Gillette, 221 E. 20th Street, Chicago, Ill.

Business Manager, E. S. Gillette 221 E. 20th Street, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Gillette Publishing Co., 221 E. 20th St., Chicago, Ill.

H. P. Gillette, 221 E. 20th St., Chicago, Ill.

E. S. Gillette, 221 E. 20th St., Chicago, Ill.

Mrs. R. W. Hume, 303 S. Stone Ave. La-Grange, Ill.

Winifred Gillette, Edgewater Beach Hotel, Chicago, Ill.

Commonwealth Title Ins. & Trust Co., Chestnut & 12th Sts., Philadelphia, Pa.

Louise Forsythe, 13 E. Windermere Terrace, Lansdowne, Pa.

LaVerne Louer Hellyer, Ambassador Hotel, Chicago, Ill.

3. That the known bondholders, mortagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state). None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is.....
(This information is required from daily publications only.)

E. S. GILLETTE.
Business Manager.

Sworn to and subscribed before me this 26th day of March, 1928.

(Seal). KITTIE C. WOULFE.

(My commission expires Feb. 9th 1930.)